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Research Paper

Signal detection among young adults using visual target detection test

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ABSTRACT

Signal detection deals with the measurement of ability to differentiate between patterns of information and to keep away from the distraction. Cues are generally presented through visual or verbal. Visual search is an effective and a common method of information processing. In this study, a total sample (N=270) both male and female of age ranging from 17 to 24 years with Mage = 21.8, SD = 2.72 attempted a computer based visual target detection test. Different types of stimuli and different mode of presentation was adopted involving black and white, colour and randomly positioned picture cues. Main measure involved is the scrutiny of the hits, misses, false alarm and correct rejection along with reaction time. Then, the observer recorded data is fed in SPSS 22.0 for analysing the results and discussion. Results indicate that there is no significant difference between males and females with respect to hits, misses, false alarm and correct rejection. Random sets evoked more no of miss/false alarms. There is a significant difference in reaction time between males and females with regard to black and white stimuli. The study gave the authors an insight into the understanding of signal detection phenomenon and its potential application areas like military services, data analytics etc, where the eye-limb coordination is essential.

Keywords: *Signal detection, Visual Search, Computerised testing*

Signal Detection Theory (SDT) is a framework used in predicting human psycho-physical thresholds in the presence of some uncertainty or distraction. The theory gives few postulates to predict the response time to spot a target in order to describe search accuracy. A theory predicting how and when we detect the presence of a faint stimulus (signal) amid background stimulation (noise). The theory assumes that there is no single absolute threshold and that detection depends partly on a person's experience, expectations, motivation and level of fatigue (Macmillan, 1993). Signal detection methods have many real-world applications. It can be used to screen applicants for jobs requiring keen hearing to training air-traffic controllers, and jobs requiring keen watching like radar operators, whose decisions about the presence or absence of a blip on a radar screen may mean the difference between life and death. The radar operator has to distinguish in coming enemy missiles from radar images of passing birds. The theory also has an important

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application to crucial tasks, such as identifying bombs put through airport X-ray machines (Wixted, 2020). The measurement in SDT involves the perceptual capacity of the observer *(d')* and his subjective perceptual criterion for selecting one category over another *(β)* (Stanislaw & Todorov, 1999)

Executive functioning is defined as managing the cognitive processes including working memory, cognitive flexibility, response selection, planning and execution of tasks. One of the executive functions is 'Visual Search' which involves spotting a target among various distracters. In a usual context, there would be a single target that would differ from the distracters along one or more dimensions (Verghese, 2011). Cortical stimulation is another important facet of visual search. The alpha phase of visual processing *(7-13 Hz)* is receiving a lot of attention when it comes to visual processing. Neuroscientists working in this area concluded that alpha phase gates visual inputs through cortical excitability modulation. (De Graff et.al. 2020) Eye-tracking provides a means to characterize the spatio-temporal properties of a trial. It helps in understanding the attention during visual search (Hollingworth & Bale, 2019)

Components of Visual Search

In visual search tasks, observers typically look for one or more target items among distracting items. Visual search lies at an important intersection between vision and attention. It is impossible to fully process everything in the visual scene at once. Most acts of visual object recognition require that resources be directed to one (or a very few) items. Visual selective attention is used to restrict processing for this purpose (Wolfe, 2018)

Serial Search: Search times increase with the number of elements in the display. One example is the conjunctiva search. In this, the target differs from the distracters by a unique combination of features; the target cannot be characterized by a single unique attribute. RT increases with the increase in the number of distracters. In developing tests to identify the target detection abilities of the analyst, the research concluded that multi-sensory audio/tactile cueing improves visual search in terms of speed and accuracy and reduced the amount of cognitive workload required (Hancock, 2013).

Parallel Search: Search times are independent of the number of items in the display. When the target and the distracters differ in one physical dimension or stimulus attribute (Eckstein, 2001). In this search, reaction time is independent of the number of distracters.

Guided Search: Proposes that a limited set of attributes, derived from early vision, which can be used to guide the selection of visual objects. The bottleneck represents performance on visual search tasks when an observer looks for one object in a field containing distracting objects. Bottleneck and recognition processes are modelled using an asynchronous version of a diffusion process (Wolfe, 2007). Research and theories on visual search often focus on visual guidance to explain differences in search. Guidance is the tuning of attention to target features and facilities search because distracters that do not show target features can be more effectively ignored (Skipping). As a general rule the better the guidance is, the more efficient search is (Hortsmann, 2019).

The search procedure is considered to be a two-stage process. The first stage is known as Pre-attentive stage in which the processing occurs before the influence of attention. The elements in this stage operate based on parallel search. In stage-II also known as Serial stage, that occurs only if the target fails to be isolated in the first stage. It depends on

attention to focus on single items or group of items in turn and operates in conjuctive search (Treisman, 1980).

According to Wolfe (2002), difference between the distracter and target may be found in terms of the following dimensions: Colour differences, orientation, curvature, vernier offset, size spatial frequency, motion, shape, stereoscopic depth and gloss. A study to examine the target distracter discriminability in visual search found that the target-confusable distracters increase latencies, to detect targets, even when the number of such distracters is not known in advance by the subject (Pashler, 1987).

Factors influencing performance of visual search

Infrequent targets: Rarer, the target, higher the rate of missing it. This is called Low prevalence effect. This indices the classic vigilance decrement function.
Ambiguity: More ambiguous the stimulus, higher the rate of miss
Number of stimuli: Greater the number of stimuli, higher the chance of missing the target
Threshold: Stimuli marginally above the sensory threshold of observation, greater the chance of miss (Hancock et al., 2013)

Few researchers have proposed that SDT can be used as a model in applied research of visual search. According to SDT, the elements in visual search display are internally represented as independent, noisy random variables. Further in SDT framework, the stimulus as a target or distracter is based on the one that produces greater response in a filter selective for the target. Greater the difference in the characteristics of the stimulus and distracter, larger is the response evoked by the target. The failure to efficiently detect the target stimulus has serious consequences in many practical situations across the world, one of which is military endeavours. Example of a missed enemy target can lead to potential damage and loss of life.

Synthetic Aperture Radar (SAR) imaging systems have been widely used in both civil and military setups. However, due to image data exponentially increasing, there is a growing need for novel target automatic detection and recognition technologies. In recent years, visual attention mechanism has helped human beings deal effectively with complex visual signals. (Fei et.al., 2015). Target vision detection has great practical value and application prospect. The application fields include intelligent video surveillance, robot navigation, automatic positioning and focusing in digital cameras, aircraft aerial photograph or satellite image detection, and obstacle detection in vehicle camera images. At the same time, target vision detection is also an important prerequisite for many high levels visual processing and analysis tasks. The behaviour analysis, event detection, scene semantic understanding and so on require the use of image processing and pattern recognition technology to detect the objects in the image, determine the semantic types of these objects to the image, and mark the target pairs (Xu & Huang, 2018). One study found out the usage of eye shield does not affect the performance of football players on reaction time and target detection (Miller et.al, 2019). Similarly, application oriented researches are being carried out. A study is using the context-aware correlation filter tracker and working on developing an accurate tracking model. Improving the visual target tracking response is the main objective (Xu et.al, 2020). The ability to detect visual targets in complex background is affected by factors such as stimulus saliency and top-down attention (Luo & Ding, 2020). In the present study also, the importance is given to those factors while constructing the test.

Aim and objectives

The importance of visual search in the field of application is multi-fold and its significance has been well-understood in the existing literature. However, the field needs more impetus in terms of research and usage in the Armed Forces, Para Military forces and other civil services. A computer based assessment tool will be even handier when it comes to reducing the time on task and easy method of getting the output required. This study is intended to:

1. To assess the response patterns of Hit, Misses, False Alarms and Correct Rejection and reaction time on visual target detection task amongst the participants under the study.
2. To determine the gender difference between the males and females with respect to the response patterns of Hit, Misses, False Alarms, Correct Rejection and Reaction Time amongst the participants under the study.

Hypotheses

Based on the review of literature, the following alternate hypotheses were made which will be subjected to statistical analysis.

$H_{1.}$ There will be a significant difference between male and female participants in Hit, miss, false Alarm and correct rejection rate in the visual target detection test.

$H_{2.}$ There will be a significant difference between male and female participants in their reaction time to visual target detection test.

METHODOLOGY

Participants

A total sample consist of N=270 male and female participants in the age range of 17-24 years with M_{age} = 21.8, S.D = 2.72 who has shown interest in joining armed forces participated in the study. The samples represent all the zones of India such as North zone, south zone, north-east zone, west zone and central zones. All participants reported having normal or corrected to normal acuity. The samples are randomly allocated to three different groups based on the type of visual stimuli they are performing in the visual target detection. i.e. Black and white, Colored and Random. 43% (n=58) of males attempted black and white stimuli, while 27% (n=36) attempted colored stimuli and 29% (n= 40) attempted random stimuli. In the female group, 33% of the samples (n=46) attempted black and white stimuli whereas 38% (n=52) attempted colored stimuli and 28% (n=38) attempted random stimuli. It is seen that 19% of the samples belong to Higher Secondary School, 53% of the samples belong to under graduation programs and 28% of the samples belong to post graduation and higher educational levels.

Procedure for development of tasks

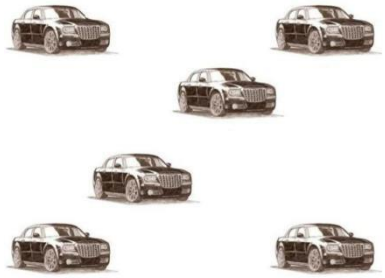
Based on the above procedure, one of the aims of the current study is to develop a Computer Adaptive Visual Target Detection Test. Items were generated using psychometric principles and methodology. Items were graded as simple, mild-complex and complex based on the difficulty level.

Categorization of the content is as follows:

- *Man:* Great personalities of Wars and/ or public figures may be used as stimuli to identify the ability of the subject to detect the target from the distracters.
- *Weapon:* Different types of weapons may be used as stimuli to check the ability of the subject to detect the target from among the distracters.

- *Buildings*: Important structures of any country may be high risk targets of attack. Therefore, a country requires analysts with higher order functioning for detection of any unfamiliar activities. For this purpose, buildings have also been included in the list of stimuli for the candidate to identify the targets from among the set of distracters.
- *Vehicle:* The new avenues and capacities developed to detect targets range from modern vehicles equipped with radars and ultrasonic sensors to displays derived from satellite detection. This is supplemented by Unmanned Aerial Vehicles (UAVs) to support detection by ground soldiers.

Figure-1 Example of a stimulus picture vehicle



In one of the above images, reflector side mirror of the car is missing. The task is to identify presence of stimulus and position no.1 as location.

Parameters to develop an item for visual search

When the subject is presented with a stimulus, there are two main components to the decision making process (Heeger, 1997):

- *Stimulus strength***:** Required in order to elicit a response from the subject
- *Criterion:* This component requires the subject to use his/her own judgement in making a decision. It involves processing, reaction time and span of attention.
- *Human brain processing*: One of the assumptions of Signal Detection Theory is that, any stimulus, irrespective of it being be a target or distracter, has the potential to elicit an internal response in the subject. On an average, the internal response elicited to the target may be different from that elicited to the distracters.
- *Reaction time:* The observer's reaction time for finding the target is measured as a function of the number of distracters in the display. In feature search (parallel processing), the reaction time is independent of the number of distracters. However, in conjunction search (serial processing), the reaction time increases with the increase in the number of distracters.
- *Span of attention*: It refers to the number of objects which could be grasped in one short presentation. Span of absolute judgment can be distinguished into seven categories and span of attention encompasses about six objects at a glance (Miller, 1956).

Increased exposure time → Increased implicit perceptual memory

Increased exposure time → Increased perceptual and conceptual memory, when the measures are explicit. Manipulations in exposure time lead to dissociations in implicit, but, not explicit memory

In absolute judgement i.e., classification of sensory stimuli into categories like that of brightness, loudness, pitch, extent etc, 7+/-2 is the effective number of categories that the subject can maintain.
In short term recall, 7+/-2 defines the number of items the subject can recall (Sperling, 1988)

Instruments

1. ***Black and white stimuli:*** This stimuli version consists of 3 sets with a total of 84 black and white images of man, weapon, building and vehicles; that are presented to the participants. These were chosen in view of the large number of objects with subtle differences in many features. The objects appeared were chosen from open source database with a keen attention to lightning, pose, and feature differences. One object was selected to serve as the target, five additional objects served as distracters.
2. ***Colored stimuli:*** This stimuli version also consists of 3 sets having a total of 84 colored images that are presented to the subject. It also involved different types of objects such as weapons, vehicles, building etc,. But it is present in coloured form.
3. ***Random stimuli:*** The random stimuli group consists of 40 images categorized in 4 groups - building, vehicle, weapon and man respectively. Each category consists of 10 black and white images that are placed randomly in each slide.
4. ***Procedure and conduct of Experiment:*** The study being experimental in nature involves the experiment to be conducted in a controlled environment. A dedicated well-lit and ventilated room was arranged for conducting the experiments. The task involved the participants to be seated in a chair in front of computer and perform the task which would take about approximately 25-30 mins. The task was conducted on an individual basis. Informed consent was obtained from participant before the beginning of the task. The participant is made to sit in front of the computer and the researcher briefs him/her about the instructions for the task in detail. The participants were made to sit before computer screen at a distance of 60cms.The resolution of each visual stimulus, target or distractor, was 640×480 pixels that was constant across all sets and types of stimuli. The participant reads and understands the instructions well. If there is any discrepancy in taking the test, the participant gets all his doubts clarified from the researcher and he/she has been told thoroughly that no such doubts would be encouraged after the test has progressed.Once the instructions are delivered, the participant starts taking the test in the order of Set-1,2,3 of any of the stimuli type assigned randomly to him/her i.e. Black and white, Colour or random. The participant has been allowed to do the task on their own while the instructor/researcher remains available behind them to record the data of the performance of the participant during the task. The researcher also should remain very much alert so as to record each and every finding during the entire 25-30 mins so as to avoid statistical errors. Once the task is completed, the feedback would be taken from the participant about the test before he/she leaves the testing room for improvement of the delivery of the tests to the participants since it forms the first hand data.

Statistical Analysis

The first step in the analysis was to systematically enter the data and accumulate it in a data sheet. SPSS v.22.0 was used for the purpose of statistical analysis. The output has been briefly discussed with the tables and interpreted further in the discussion. Descriptive statistics such as mean, standard deviation, skewness and kurtosis were calculated for continuous data of gender on the parameters of hit/false alarm and reaction time.

The groups i.e. males and females were compared using Independent Sample t-test to determine whether there are significant differences in hit/false alarm rate and reaction time. In addition, discriminability index is also calculated using appropriate formulae.

RESULTS

The study is aimed at assessing the response patterns of hit, miss, false alarm and correct rejection through Visual Target Detection Test (VTDT). Mean (S.D) were calculated for male and female groups in various response categories such as black and white, coloured and random. In all the response categories, the participants gave maximum 'Yes' and Correct (Hit) responses ($M_{Black\ \&\ white}$ = 83.7, $M_{Miss/FA}$ = 0.31; $M_{Coloured}$ = 83.6, $M_{Miss/FA}$ = 0.41; M_{Random} =37.9,$M_{miss/FA}$ = 2.60)

Table 1. Descriptive statistics and normality of distribution of data

Stimuli	Sample	Type of Stimuli	Mean No. of Hits/ Correct rejection	Mean No. of False alarms/ Miss	Mean Reaction time (RT)	S D	Skewness		Kurtosis	
							Stat.	Std. Error	Stat	Std. Error
Black & White	Male	Man	83.7	0.31	79357	36663	0.363	0.314	-0.01	0.618
		Weapon	83.4	0.62	77759	34950	0.018	0.314	0.222	0.618
		Building	81.1	2.81	96345	39475	-0.439	0.314	-0.102	0.618
		Vehicle	83.6	0.41	77500	49215	2.72	0.314	10.36	0.618
	Female	Man	83.8	0.13	94261	30120	-0.515	0.35	-1.092	0.688
		Weapon	83.0	1.02	95087	31970	0.487	0.35	-1.093	0.688
		Building	80.2	3.78	98130	28097	-0.194	0.35	-1.593	0.688
		Vehicle	83.2	0.89	91696	44176	1.128	0.35	0.17	0.688
Colour	Male	Man	83.3	0.61	85139	35757	0.288	0.393	-0.641	0.768
		Weapon	83.1	0.88	93667	36883	0.804	0.393	-0.038	0.768
		Building	83.0	1.00	98694	30945	0.21	0.393	-0.121	0.768
		Vehicle	83.6	0.41	79528	28396	0.731	0.393	-0.64	0.768
	Female	Man	81.8	0.60	83717	34591	0.31	0.327	-0.741	0.644
		Weapon	81.5	0.88	91189	36189	0.909	0.327	0.105	0.644
		Building	81.4	0.98	96736	34639	0.344	0.327	-0.118	0.644
		Vehicle	81.9	0.52	75057	28060	0.874	0.327	-0.288	0.644
Random	Male	Man	37.4	2.60	131170	55928	0.53	0.374	-0.622	0.733
		Weapon	37.8	2.15	110220	37121	0.424	0.374	0.186	0.733
		Building	37.9	2.08	103600	31317	0.117	0.374	-0.273	0.733
		Vehicle	39.6	0.35	80675	34524	0.205	0.374	-1.49	0.733
	Female	Man	37.4	2.55	124160	47565	0.753	0.383	0.134	0.75
		Weapon	37.8	2.23	105080	34700	0.409	0.383	0.1	0.75
		Building	37.9	2.08	99658	31817	0.292	0.383	-0.438	0.75
		Vehicle	39.6	0.34	77737	30341	0.341	0.383	-1.17	0.75

When it comes to mean no of errors, the maximum score was obtained both in males ($M_{B\&w\ Building}$ = 2.81 & 3.78). This can be interpreted as the subjects having difficulty in identifying

Miss/false alarm in Building stimuli. Both males and females seem to have identical mean scores in Random type of stimuli which indicates that there is no gender difference in random stimuli. Both the groups gave lowest 'Yes' and incorrect (False Alarm) responses in both the testing conditions. Considering the rule of thumb for Skewness (-1 to +1) and Kurtosis (-2 to +2), all the distributions met the criteria of normality with an exception in the value of Vehicle stimuli (Skewness = 2.72, Kurtosis = 10.36)

Table 2: Shows hit and false alarm rate

	Males (n=134)			
	Hit rate	**False Alarm rate**	**Discriminability index (d')**	**Response Bias Ratio (β)**
Black & White	99.50%	4.70 %	4.252	0.147
Coloured	99.77%	4.76 %	4.501	0.073
Random	98.34%	17.99 %	3.045	0.158
Females (n=136)				
Black & white	99.19%	7.14%	3.84	0.158
Coloured	99.63 %	7.63 %	4.145	0.082
Random	98.04 %	15.20 %	3.090	0.202

From the above table, it is seen that the hit rate of both males and females with respect to all three different stimuli increased to almost 100% and false alarm rate varied between 4% to 18%. The false alarm rate for random stimuli which stand at 17.99% for males and 15.20% for females indicate lower level of discriminability *(d')*. There is no significant difference between males and females with respect to hit and false alarm rate. The response bias ratio ($\beta=0.156<1$) indicates decreased biasness of participants towards giving 'no' response in both male and female group.

Figure-2 Shows comparison of male and female (d') with regard to black and white stimuli

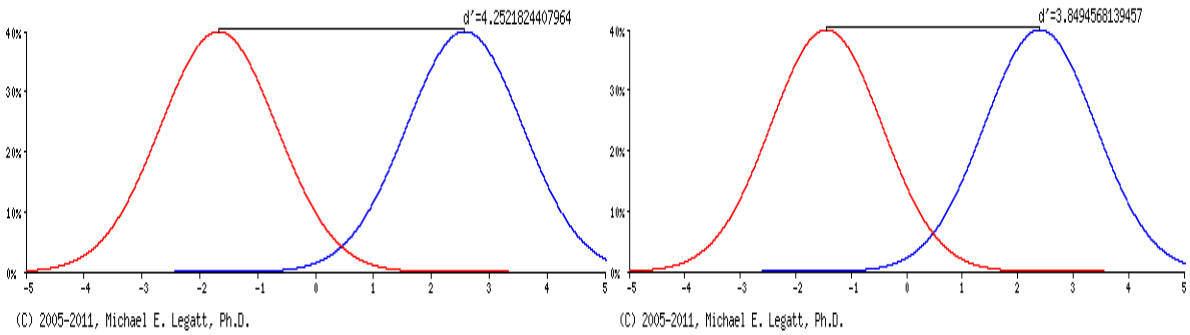


Figure-3 Shows comparison of male and female (d') with regard to coloured stimuli

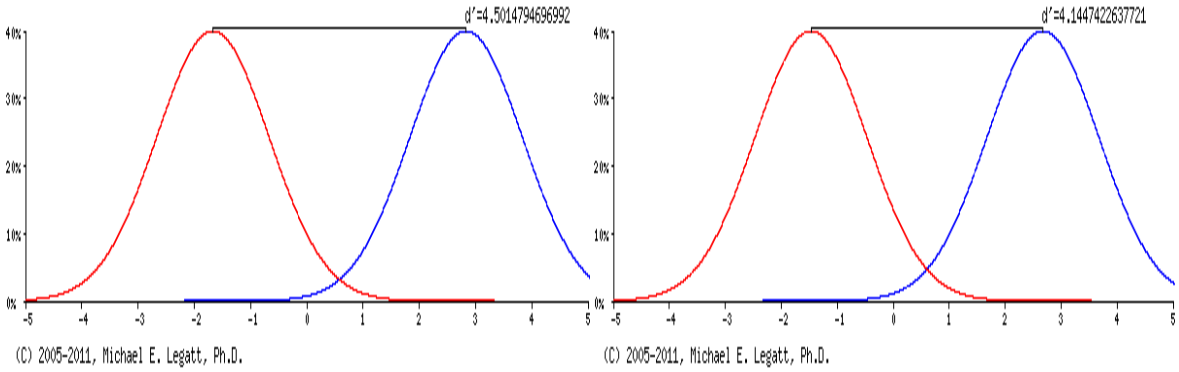
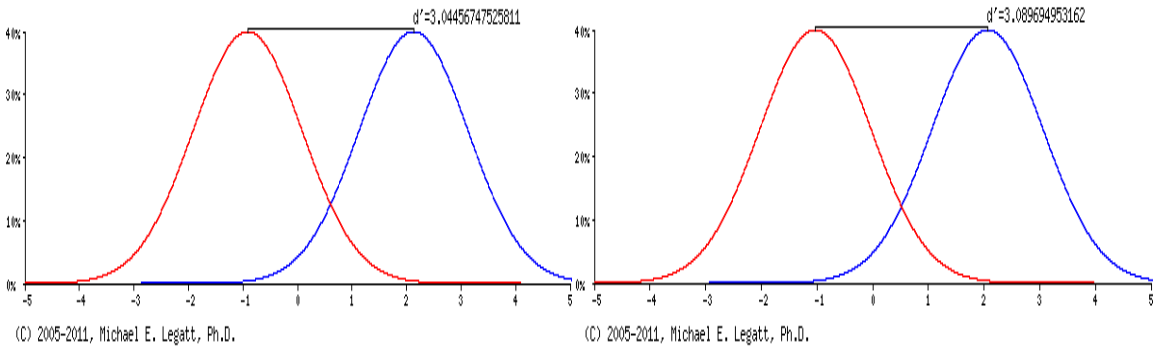


Figure-4 Shows comparison of male and female (d') with regard to random stimuli



From all three figures above, it is evident that the normal distribution curve of the (d') score which is a yardstick for measuring signal detection is comparatively identical which shows that there is no gender difference in the hit and false alarm rate when it comes to different types of stimuli i.e. Black and white, coloured and random

Table-3: Independent Sample t-test showing the gender differences in miss/false alarm with respect to different type of stimuli

	t-test for Equality of means							
	Mean Differences	SD	Std. Error Mean	95% Confidence Interval of the Difference		t	df	*Sig. (2-tailed)
				Lower	Upper			
Black and white	-.095	1.77	.098	-.29	.098	-.967	103	.334
Coloured	-.187	1.69	.099	-.38	.008	-1.880	87	.061
Random	.042	1.88	.108	-.16	.255	.396	77	.693

P>.05

From the above table, it is very evident that there is no significant difference in terms of miss/false alarms between male and female groups attempting various sets (p= 0.334, 0.061, 0.693>0.05). Hence, the first hypothesis (H_1) is rejected and null hypothesis (H_0) has been

proved. Both males and females commit same no of miss/false alarms which indicates very minimal involvement of the concept of lateralization of the brain into right brain and left brain.

Table -4: Independent sample t-test showing the gender difference in black and white stimuli with respect to reaction time (RT)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Man	.644	.424	-2.225	102	.028*	-14903.97	6699.59	-28192.57	-1615.36
Weapon	.103	.749	-2.607	102	.011*	-17328.33	6647.22	-30513.08	-4143.58
Building	2.843	.095	-.259	102	.796	-1785.60	6893.67	-15459.17	11887.95
Vehicle	.740	.392	-1.528	102	.130	-14195.65	9291.04	-32624.40	4233.09

*$P<.05$

From Table no: 4, it is observed that the males and females have a significant difference in the reaction time when it comes to Man and weapon type of stimuli (t = -2.225, -2.607; 2-tailed Sig. = 0.028, 0.011<0.05). However, when it comes to the other two stimuli i.e. Building and vehicle, there is no significant difference between male and female groups in the reaction time. The observed differences could be due to difficulties in sustaining attention and concentration, prolonged time taken for finding out target objects though they are repetitive, the participants might become lethargic.

Table: 5 Independent sample t-test showing the gender difference in coloured stimuli with respect to reaction time (RT)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Man	.003	.954	.188	87	.852	1421.90	7573.19	-13630.64	16474.45
Weapon	.026	.873	.315	87	.754	2477.98	7876.67	-13177.76	18133.73
Building	.355	.553	.273	87	.785	1958.59	7171.04	-12294.63	16211.82
Vehicle	.091	.763	.734	87	.465	4471.17	6089.73	-7632.82	16575.17

$p>.05$

As compared to the previous table, the level of significance here is much higher which indicates that there is no significant difference between males and females. Moreover, the

coloured stimuli evoke responses that are identical in both the genders. The reaction time is shorter as well when compared with black and white and random stimuli. The colour discrimination component of vision helps us understand why the coloured stimuli are picked up faster in the visual search.

Table 6: Independent sample t-test showing the gender difference in random stimuli with respect to reaction time (RT)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Man	1.045	.310	.595	76	.553	7017.10	11785.30	-16455.37	30489.58
Weapon	.068	.795	.632	76	.529	5146.05	8146.78	-11079.66	21371.77
Building	.024	.878	.551	76	.583	3942.10	7149.64	-10297.64	18181.85
Vehicle	1.716	.194	.398	76	.691	2938.15	7374.64	-11749.71	17626.03

p>.05

From the table above, it is evident that the males and females do not differ significantly with respect to their reaction time in random type of stimuli presentation (2-tailed Sig. = 0.553, 0.529, 0.583 and 0.691). This indicates that when presented in a random manner, the stimulus responses evoke the similar RT speed amongst the males and females

DISCUSSION

In this study, we explored the response patterns of males and females with respect to their signal detection ability i.e. ability to identify hits, misses, false alarms and correct rejections along with reaction time in a visual target detection test. The first phase is about development of stimuli pictures. For this purpose, images with items for target identification and location were developed in three different templates. i.e. Black and white, coloured and random. We also worked on identifying whether there are any significant gender differences in the above mentioned measures. The findings reveal that the majority of participants either scored hit/correct rejections in all types of stimuli i.e. Black and white, coloured and random. Only the building sub-type evoked few miss/false alarms which could be due to the difficulty of perceiving the figure against the ground or presence of two similar targets. Both males and females had scored more no of false alarms in this stimulus.

Position-related errors are much lesser when compared to identification errors because, only when the identification is done, the error of position comes into place. Henceforth, error in identification is by default an error in locating the target. Weapon stimuli had evoked the maximum no of errors in both male and female participants with respect to participants misinterpreting the location of the target while Vehicle stimuli evoked the least. This could be because the sample comprised of college going students being more exposed to vehicles over weapons. Changes in texture are more difficult to identify which was evident in the maximum no. of errors committed in Building type stimuli. Also, response is faster to physically identical than physically distinct targets (David & Algom, 2009).

The reaction time of random set is higher when compared to that of black & white and coloured. This indicates that the time taken to identify and locate the target increases with the increase in difficulty in visual search. The difficulty in visual search is brought through change in sequence of presentation, position of the target etc., which would target to elicit higher cognitive processes. When it comes to the gender difference, the males and females vary significantly in their reaction time in black and white stimuli (Man and weapon). All the other types of stimuli show no difference between both the groups in either reaction time or hit and false alarm rate.

In addition, the component of decision-making has also been assessed indirectly using the signal detection theory (Anderson, 2015). The general premise of SDT is that decisions are made against the background of uncertainty and the goal of the participant is to tease out the decision signal from background noise. The discriminability scores indicate that random stimuli have lower level of discriminability i.e. poor decision making when compared to other two types of stimuli.

In a previous study, Hancock (2013) has given the two process of target detection i.e. Attention and Decoding which covers the major cognitive components of focussed attention, target selection, target identification, target retention, target execution and response inhibition. This study has tried its best efforts to emphasize on all these aspects of the cognitive processes involved in Target detection test. Visual cues can elicit better response from the organisms than that of the auditory ones (Lupyan, 2010). This postulate had been verified in the present study.

Colour identification plays an important role in reducing the reaction time and efficient target identification than the location of the target itself (Spence, 2001). This was very much seen in the present study. When the stimulus is repetitive, i.e. in terms of black and white and colour, the reaction time is much lesser as compared to the random set where the stimulus is arranged in alternative manner. This could be explained by the practice effect and attunement to a particular set of responding when it comes to the same stimulus being repeated. Changes in texture are more difficult to identify than that of colour, present/absent of some component which was evident in the maximum no. of errors committed in Building type stimuli. Cultural and socio-economic differences may also have an external influence in terms of the exposure to the stimuli previously which was evident in the case of few outliers in terms of reaction time as well as errors committed.

Spatio-temporal brain representation of target detection is subject specific, yet for each subject it is consistent across trials (Alpert et al., 2013) hence, no significant difference in terms of false alarms/miss committed between male and female groups attempting various sets was observed. Cultural and socio-economic differences may also have an external influence in terms of the exposure to the stimuli previously which was evident in the case of few outliers in terms of reaction time as well as errors committed. One analysis that could not be done is age related comparison since the sample group was more or less from same age. One study has found that reaction time increases with aging and eccentricity whereas in contrast to target detection, there is no interaction between aging and eccentricity (Gruber, 2014).

The study aimed at developing computerised Visual target detection and the data obtained stands as a testimonial to the validity of the test. No major problems were reported by any of the participants during the conduction of the tests. The study followed the principle of Signal

Detection. i.e. Hit, Miss, False Alarm and Identification and added on an extra component of Reaction time which uncovers many aspects of the cognitive processes including the response inhibition and sustained attention.

CONCLUSION

The study was conducted over a span of many months with ample time spent on finalizing the stimulus pictures which followed the cardinal principles of Signal Detection Theory. Data collection was done over a sample of N=270 participants spanning about 5-6 months of time. The researcher made maximum effort to keep the participant group as a homogenous one with almost equal distribution among male and females. The study was generally constructed based on the existing literature in the field and the outcome was found to be satisfactory though there were not significant differences with regard to reaction time and errors amongst both the genders as well as the different stimuli overall.

Practical Implications

The study can very well be replicated in the armed forces and other vocational set ups where the role of visual target detection and response inhibition is very much required. Furthermore, the tasks can be used for interventional purposes with children and adolescents having Attention related disorders such as ADHD and Specific Learning Disability (Hawelka & Wimmer, 2008). It can also be extended to geriatric population and related diseases such as Alzheimer's (Vallejo et al., 2016). The study can be useful to develop screening and training measures based on vigilance, especially in relation to military, Para-military, navigation, combat and battle zones and crowded or overpopulated areas.

Directions for Future Research

Future research should focus on the replication of the study on a larger sample consisting of participants with different levels of education and inclusion of samples from different age, culture and socio-economic strata. It would help in generalization of the findings. Specialized Visual Target Detection Tests for recruitment and training in various fields can be worked upon. Efforts could be made to rule out the effect of dispositional factors. Correlation of target detection with other processes of mental abilities can also be considered for better understanding and establishing the validity. Advance measures such as Fuzzy Signal Detection Theory (FSDT) could be used to improve measurement of performance in domains in which stimuli do not fall into discrete, mutually exclusive categories (Szalma & Hancock, 2013)

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Conflict of Interest

No conflicts of interest expressed or reported to the author(s)

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