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Relationship between Intelligence and Attention; A Review Study

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ABSTRACT

Introduction; Despite researches in past 100 years in the field of human's mental ability, relationship between attention and intelligence is complex and controversial yet. Theoretically, relationship between intelligence and attention is expected, although intelligent capabilities can't be only attributed to attention, but controlled attention is posed as mediator variable that has common variance with general intelligence.Methodology; In current paper, beside review of some studies in resent two decades about relationship between attention and intelligence from theoretical perspective, available empirical evidence are collected about relationship between this two structure and finally are discussed about the differences in results. Result; Nature of relationship between intelligence and attention is not determined precisely, but converge results of previous studies show that attention is strong predictor in general intelligence or fluid intelligence (abstract reasoning ability in new situations and environment). Also among different attentions, sustained and controlled (voluntary) attentions have shown stronger relationship. Researchers in explanation of available differences in the degree of relation between these two have reported difference in theoretical definitions of intelligence and attention, difference in measurement tool for these two and finally difference in application of statistical methods.

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INTRODUCTION

At any moment we are exposed to a continuous stream of sensory information that its extent is beyond our understanding and cognitive process of our brain. Attention is a mechanism that prevents accumulation of extra information in nervous system and at the same time, enables us to do actions, making-discussion and reactions against surround environment. Even the cleverest people should be equipped with mechanism of attention and cognitive resources management for screening and process of information [13].

Cattle defined fluid intelligence as: ability to understand the relationships, independent from experience or guideline about that. Fluid intelligence is the ability of thinking, abstract reasoning and problem-solving and this ability is considered independent from learning, experience and teaching. Examples of usage of fluid intelligence include question-solving and access to problem-solving strategy. Fluid intelligence is against crystalized intelligence that includes learning and former experiences. The situations that crystalized intelligence need them consists of reading and comprehension and words tests. This kind of intelligence is based on realities and rooted in past experiences and becomes stronger by becoming older and gaining knowledge and new understandings. Fluid and crystalized intelligence are constituents of general capability of learning, reasoning, problem-solving and activities that most of people remember them as intelligential actions. These are complementing each other and they control human's learning [12].

Importance of attention's role in intelligence is not a new discussion. Spearman studied this topic in detail and in 1909, Burt provided empirical evidences in this field. Binet, the father of IQ tests, paid attention to the role of attention in general intelligence and William James also referring to the extent of people's intelligence power noted that effective variables on intelligence are endless.

The majority knows the attention as a key element of intelligence. Difficulty of study the relationship between attention and intelligence is relatively because of their intangibility. In other words, as whereas both intelligence and attention are occult or silent, their direct observation and assessment is impossible and as result,

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their measurement is indirectly and by using tools that are considered as these variable's reflectors. In this paper, first of all the concept of attention will be assessed and then the theoretical framework of relationship between attention and intelligence will be posed. Finally, studied researches about relationships between intelligence and attention will be reviewed.

Definition of attention:

Wiliam James described the problem in the definition of attention as: by introspection we can concluded that all we know what attention is but access to an agreed definition is so hard. Helgason [13] proposed four definitions for attention. In the first definition, mental facilities are defined as mind director to a thing or event. In the second definition, attention is mental focus on a thing or thought that is with the aim of limiting rang of motives or preferring, selecting and highlighting some motives among complex set of motives.

The third definition is mentioned to attention as a consciousness state that its main characteristic is focus. In the fourth definition, attention is the capacity of selective maintenance or keeping concentration. The last definition found definition as cognitive process of selective focus on one dimension from surround environment and at the same time, neglecting other dimensions in order to allocation of processing resources. Some consider that attention is only for keeping and recording information through activating them. In contrast, other groups of researchers mention to inhibition role instead of activation and finally some groups know attention equivalent controlled cognition [25].

Types of attention:

Certainly there is a qualitative difference between attention as ability to controlled (conscious) processing and automatic processing. Controlled processing is the result of effort and is affected by limitations in capability of attention. Cognitive control acts by using professional mechanisms like activations and inhibitions. Totally, controlled attention is voluntary cognitive activity that acts through proper activation of brain circuits, prevention of irrelevant information and strong unconnected racing back responses with tasks. Also voluntary attention is called top-down processing, endogenous attention, controlled attention, executive or purposeful that is controlled by frontal cortex and basal ganglia. Depending on functional type in each desired task, there are various kinds of voluntary attention and related issues:

1. One of the attentions that can find it vigilance or sustained attention is proposed in tasks that need to maintain attention such as when attention of a person is in the service of one specific motive. As a result, the people who can keep more attention, would response to the motives faster (of course some distinguish difference between sustained attention and vigilance and notice that in sustained attention the time of concentration is less but in vigilance, focus is deeper. In most resources this two are considered synonyms).
2. Second type is divided attention or multiple attentions. In related tasks, multiple attentions should be done simultaneously with two or more tasks.
3. Other type is selective attention and is proposed when various information or resources are offered to a person and he should select one among the others and neglect others.
4. Span attention refers to the duration time that a person can concentrate on a task without disruption and distraction.
5. Attention shift refers to a process that current information is replaced by new information in brain. The information could be sensational or abstract.
6. Visual search or audio search refers to a perceptual task that requires overview and active of audio or visual environment for identification of targeted motive among other similar motives.

Also attention plays various roles in related tasks like vigilance, divided attention and selective attention, the only thing that is considered in these three common fields, is element of control. Control of attention means capacity of a person to select a subject too attention and neglect. In other words, attention is done by different methods but using voluntary attention depends on individual's executive control and this executive control has limited capacity. In other words, performance of a person in selective attention and divided attention can separate people with low and high attention control ability but tasks that measure automatic attention do not have this feature.

In another classification, attention is divided into voluntary and involuntary. If we consider all mentioned attention types as voluntary, involuntary attention is a kind of instinctive mechanism of attention director that is expressed without effort, will or authorization and according to sudden motives in surround environment. Because sudden motives can be dangerous or useful (hunter or hunted), this attention is considered adaptive response (from evolutionary view). Although involuntary attention does not need to control but sustainability and maintenance of this attention need control (in that case, it is not involuntary). Involuntary attention is called bottom-up processing, stimulated attention from environment and exogenous. This type of attention refers to a processing that object's features cause its motivation. Move or loud and sudden voice can attract the attention involuntary. This type of attention has relationship with temporal cortex activity and brainstem [16].

Also in some resources, it is mentioned in two categories: Overt attention against covert attention. Overt attention considers guidance of sense organs to motive source although convert attention relates to mental focus [2].

Relationship between executive functions and attention:

Executive functions are concepts in cognitive psychology field that are conceptualized in various ways. Executive functions are high level responsible processes of control and especially for maintenance of special mental goals and completing them is essential [4]. According to Hueghs and Graham, executive functions is a general term that hold all complex cognitive processes that are necessary in doing difficult purposeful or new tasks [1]. Executive functions consists these processes; focus of attention on related information and prevention of irrelevant information (attention and prevention), planning activities that need shifting attention and concentration between tasks (task management), sequence planning for doing tasks in order to access to goals (planning), updating information, review of active memory content for determination next steps in chain tasks (monitoring) and finally coding in working memory. [30]. Attention is one of the executive functions dimensions and it is seem that central executive functions play important role in control of attention and useful in explanation of some aspects of attention displacement and division of attention.

Relationship between attention and intelligence:

Because of the abstract of intelligence and attention, it should be paid attention to used tools and their sensitivity for measurement of each one in study and compare researches in this field. Also proposed infrastructural theory in desired research his important, because selection of tools is according to these theoretical bases and finally observed connections depend on infrastructural theory.

Among attention classifications, sustained attention has the most relationship with intelligence. As mentioned earlier, this kind of attention is keeping in-depth focus on a particular motive or situation for a relatively long time. Whatever focus is deeper, more essential resources will be available and the person steps necessary paces to carry out complex process plan proper.

It is expected that tests are designed for measurement of sustained attention that required maintenance of focus for a long time in order to identification of specific motive features with moderate complexity. We also expect that processing capacity influences on individual's response [27].

According to mainline is access to mental processing or in other words is a path that consciousness way should go through that. In information processing perspective, it is attended to the relationship between intelligence and cognitive processes. High level cognitive processes are required for carrying out intelligent tests, since it enables one's cognitive processes for doing mental activities such as problem-solving and reasoning [27]. The belief that intelligent abilities are simply due to the speed of information processing, reductionism is considered extreme and does not offer a good explanation mechanism. In general, two approaches have been proposed in this field.

In the first perspective, some researchers posed that the relationship between intelligence and speed of information processing is nervous reflector. In this perspective, neuronal speed or neurology is considered and personal differences in intelligence are arising from difference in mental speed. According to this view, the people who do the mental operations faster, have more effective mental processing and lose less information during the time. Evolutionary studies supports from the study of nerve compression and making myelin effects on elderly's nerve guidance speed but empirical evidences and required neurology for supporting this view are inadequate and contradictory [33].

The second perspective is the speed of variable information processing speed that affects other occult structure and this occult structure has decisive role in explaining the correlation between intelligence and processing speed. In other words, the processing speed has common variation with other important structure that is essential for the intelligent function. In addition, some tasks are designed for measurement of processing speed and inspection time (related structure to reaction time), have common elements with intelligent tasks, but these tasks are reflector of other variable that explain a big part of general intelligence variance or G factor. Mediate infrastructural mechanism is individual's differences in attention control ability that by two mechanisms causes relationship between speed and intelligence.

First mechanism is significant errors (or longer response time) that cause problem in achievement of goals. Individual difference is in response time arising from processing speed and reported meaningful correlations between intelligence and response time [8,14,3,22,11] and processing speed and intelligence [14] are considered empirical evidence that defend mechanism in significant errors.

Second mechanism that through that, attention in correlation between intelligence and speed plays mediate role, is complexity of task. Empirical evidence shows that simple processing speed does not require intervention of fluid intelligence but complex processing speed tasks have stronger relationships with intelligence. Therefore, tasks of processing speed have relationship with intelligence when it requires attention [34].

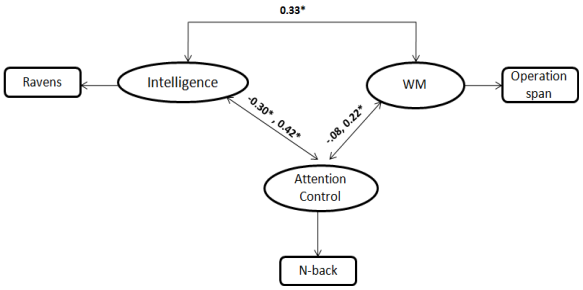
Therefore, some know attention as intelligence and mention that ability in control of attention has relationship with fluid intelligence, but it should say; Attention plays vital role in most systems that considers as high level mental functions but it is not determined how it mediates. Also according to difference between automatic processing and controlled processing in study the relationship between intelligence and attention, only studies would be proposed that include controlled attention or voluntary attention.

Also in analysis of relation between intelligence and consideration, the role of active memory should not be disregarded. Schweizer and Mosbrugger [27] analyzed the relation between consideration and active memory and their anticipator role for intelligence and the basic structure of this prediction. This research showed that two variables of active memory and consideration predict overlapping parts of intelligence. But whereas these two variables are correlated, the replacement of them is not possible. For example, when progressive metrics test of Raven is used to measure intelligence, both consideration and active memory are considered as meaningful anticipator variables but when another intelligence test (Zahlen-Verbindungs-Test) is used, consideration would be the only meaningful anticipator.

Many studies have analyzed the relation between intelligence and the ability to control consideration and the capacity of abstract arguments of individuals but these studies have not leaded in similar results. Mainly the difference observed in the results of these studies is related to the tests used for measurement of consideration or implicitly the kind of intended consideration. As mentioned before, different kinds of independent voluntary considerations are assumed so we are expecting to find different relations between these kinds of consideration and intelligence. For example, it is continuously reported that there is a meaningful statistic relation between alert and intelligence. While such relation is not seen between intelligence and divided consideration. Besides, considerable correlations found between intelligence and tests results which needed quick replacement among various cognitive operations. Such assignments are considered more complex than alert tests and need continuous devoting of resources. [28] Schweizer, Moosbrugger and Goldhammer [28] by using structural equation modeling studied relationship between types of attention (vigilance, sustained attention, focused attention, displacement of attention, divided attention, prevention, spatial attention and attention in planning) and intelligence and concluded that all types of attention have meaning ful relationship with intelligence and also comorbidity was observed between these factors in prediction of intelligence. Proposed model by these researchers was predicted 32 percent of intelligence. Cowan and Fristoe and Saults [10] in their research by using regression analysis reported that attention predicts 37 percent of intelligence variability.

Carpenter, Just and Shell [7] have reported high correlation (absolute value r=0.77) between errors in Raven test and TOH. Also, Burns, Nettelbeck and McPherson [6] have performed 17 tests of attention and 14 tests of cognitive ability and factor analysis resulted in one latent variable for intelligence and three latent variables for attention. These researchers reported correlation between intelligence and three factor of attention between 0.30 to 0.82.

Buehner *et al* [5] also studied relationship between reasoning (verbal intelligence, numerical intelligence and image intelligence) and sustained attention. These researchers did not find any meaningful relationship. Cane *et al* [16] studied relationship between active memory, control of attention and intelligence (by Raven Test) and found meaningful correlation between active memory and intelligence (r=0.33) and also between attention and intelligence (between r= -0.30 to 0.42). These results are prepared in a model. One of the proposed explanations for relationship between intelligence and active memory is that fluid intelligence depends on individual's ability in attention [33].



Model of Cane et al (2007) by using multivariate analysis:

Konig, Buhner amd Murling did not find a meaningful relationship between control of attention and fluid intelligence (r= -0.05) also in study that Saad did with 85 subjects, he could not find a meaningful relationship between selective attention and intelligence (r= -0.03) Jong and Das-smaal in the word of Wajda, Mato and Madhoosh reported the correlation between consideration and general flowing intelligence is between 0.29 and 0.34. Also in another study the correlation between intelligence and consideration of children with loss of consideration and hyperactivity were 0.31.. Sigmen, Cohen and Beckwith in a linear analysis reviewed the relation of information processing, constant consideration, executive functions and intelligence in adolescence

with visual fixation samples (the ability of gazing to a fixed point) adolescence training conditions and premature birth. One of the results of this study was that there is a meaningful relation between adolescence intelligence and consideration in childhood(r=0.36) and at least some part of the relation between consideration in childhood and intelligence in adolescence is originated in capabilities in childhood period in information processing and inhibition of powerful responses. Carter and Swanson [9] in analysis of relation between alert and intelligence in childhood concluded that although in children with low IQ there were a relation between intelligence and alert but this were not observed in the children with high IQ. These researchers recommended children who suffer from didactic problems have discounting in capacity and ability of consideration for information processing.

Performance of people in multiple tasks (ability to access multiple goals in a unit time through repeated displacement between single tasks) also has relationship with attention because is the level of attention be higher, ability of displacement would be easy and as a result, performance in multiple tasks will improve. In addition, the ability in division of time for simultaneous processing of various tasks attributes to attention [27].

Other factors are assumed that have relationship with multiple tasks consist of: working memory, fluid intelligence and extroversion [20]. However cognitive psychologists trend to study individual differences or capacity of attention rarely, and prefer study different opinions by manipulating laboratory situations between groups, but researches that have studied prediction role of attention in doing multiple tasks show that attention is meaningful predictor in this case.

Interesting point in this case is that successful relationship in doing multiple tasks by divided attention should not considered the same between intelligence and attention. Based on results that offered former, sustained attention and selective attention have the most relationship with intelligence. In another research, the relationship between intelligence and selective attention was 0.25 although divided attention had not a meaningful relationship [19].

Table of summary of results in study of relationship between intelligence and attention.

Row	Researcher (s)	Results	Date
1	Carpenter, Just and Shell	✳0.77	1990
2	Zigman, Queen Bechwith and	✳✳0.34	1997
3	Angle *et al*	0.05	1999
4	Carpenter, Atkinson and Berish	✳-0.94	2003
5	Qing *et al*	-0.05	2005
6	Friedman *et al*	✳0.29 to ✳0.31	2006
7	Boner *et al*	0.02	2006
8	Cane *et al*	✳0.18 to ✳0.42	2007
9	Poornima	0.11	2008
10	Bernz, Nettlebach and McPherson	✳0.30 to ✳✳0.82	2009
11	Saad *et al*	-0.03	2010
12	Vaida, Meto and Madhosh	✳0.31	2013
13	Khodadadi *et al*	✳0.25	2014

✳=significance in level 0.05 and ✳✳=significance in level 0.01

Results:

In study of relationship between attention and intelligence, two studies found a meaningful but weak correlation (rows 6, 12 and 13 of table) while four other studies reported a strong correlation (rows 1, 2, 8 and 10 of table). Similarly, some researchers have reported weak or unmeaning relationships between intelligence and attention (rows 3, 5, 7, 9 and 11 of table). Not getting meaningful relationships in these studies can be related to the type of tasks and used tool for attention measurement. For example, used tests for measuring different kind of attentions have different scoring and performing methods that can be effective in the degree of relationship between attention and intelligence [18].

Also Poornima did not achieve a meaningful relationship in the study of the relationship between attention as one of the attention deficit hyper activity (ADHD) elements with general, verbal and practical intelligence (No. 9 Table). In this study, a scale was used based on diagnostic criteria of diagnostic and statistical guidance of America Psychiatric Association (DSM-IV). This scale consists of 13 items for attention deficit measurement that are scored in the 4-degree Likert scale from zero to three (always, sometimes, rarely, never). Therefore the minimum and maximum score on this scale is between zero to 39. Not getting to meaningful relationship in this study can be related to the used tool. Objectivity, this tool is lower than tools that attention is quantified directly because personal judgment affects here. Another important point is that intellectual interest in children with ADHD is like other normal children, although some of them may be genius children and others are mentally retarded but the majority has medium intellectual interest [23]. Hence, it can't be desired that there is a relationship between neglect (as definition of this disorder base on DSM-IV) and intelligence of these population. Difference in the method of scoring may have negative significant correlation (row 4 in the table), typically in such cases, absolute value of correlation should be considered.

Another explanation of difference in results is related to theoretical definition of concept of intelligence and its measurement. For example, some researchers consider one of the main intelligent behaviors as the ability to tolerate irrelevant information. Researchers find weak or unmeaning relationship between intelligence and executive functions, unexpected. Because in the study of people with damaged frontal lobe such as the elderly and clinical patients, evidence about existence a strong relationship between executive functions and intelligence is reported [24].

Discussion:

However, the relationship between intelligence and attention is an inescapable concept, while it is controversial. If we consider the attention as purposeful cognitive control, so the relationship between intelligence and attention is meaningful when attention or voluntary or controlled process is considered not automatic attention. Therefore it can be concluded that attention is one of the brain's functions that impact on actions wisely, although how this mediation is, is not specified. Among different attention, sustained attention (vigilance) and selective attention have the most relation with intelligence. This relationship is strong and traceable when used task for attention measurement has required complexity. At the same time may among different types of attention, such as divided attention, there would not significant relationship with intelligence?

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