

Effects of Reducing Urban Stress on Viable Cognitive function

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ABSTRACT

Stress is an important factor affecting diseases found in modern societies. It can be harmful to both body and mind. Generally, humans can control their stress for short periods. In addition, the body has a relationship with the mind where stress enhances the release of cortisol which affects memory and memory retrieval. There are solutions to prevent stress and its effects and it is important to investigate stress reduction, especially in new city developments. This study reviews selected articles related to stress, especially urban stress and ways to prevent it. After defining what stress is, the effects of stress on the human body and mind were reviewed. Next, ways to reduce stress based on the importance of nature and nature's power of restoration were discussed. Finally, the study investigates the relationship between stress and cognitive function, with the determination that reducing stress affects viable cognitive function.

KEY WORDS: stress, urban space, memory, cognitive.

1. INTRODUCTION

Stress has become a very important topic of research as it has become so pervasive that in some countries, such as Sweden, it has been placed on a list of national diseases. (Grahn & Stigsdotter, 2003). Research has shown that stress, irritation and fatigue are closely related. Any discussion on stress must include individual human differences as well as considering the role played by hormonal and nervous systems. Stress can be considered to be the result of cultural characteristics (Maslach, 2001; Rapp, 1999; Ulrich, 2001). Many studies have debated that stress not only affects diseases in modern societies, but also affects long term memory (Nygren et al., 2002; O. T. Wolf, 2009). There is abundant evidence that shows the effects of stress on cognitive function (S.J. Lupien et al., 1997; Pruessner et al., 2010; Schwabe et al., 2007; Schwabe & Wolf, 2013).

When humans interact with their environment several factors come into focus, which raises questions such as "What are the driving forces and basic foundation of human social behavior?" Psychologists have long discussed these questions and they still debate them today (Havneskold & Risholm M. P., 1995). The most important question examined in this paper is the question regarding the relationship between stress and an individual's cognitive map.

In this study, the harmful effects of stress on the human body and memory were investigated. The results revealed that calm, stress free environments are beneficial. The available evidence outlined options for reducing stress. One such option was to turn to nature. The natural environment plays a main role in human health (Stigsdotter & Grahn, 2004). Gardens and green areas are beneficial to health (Ulrich, 1993, 2001). Stigsdotter and Grahn (2004) stated that gardens have an impact on stress by acting to prevent it.

But is immersion into the natural environment the only solution available? Most people live in an urban environment and urban designers must consider both natural and artificial elements when designing artifacts such as buildings and streets. In this paper, numerous studies have shown that the power of nature to reduce stress and aid recovery and improve cognitive mapping and which should be considered when developing cities and products.

In this study, with the help of Database University technology of Malaysia (UTM) and browsers for example Web of Science, Science Direct, Environment and Planning, Google Scholar Alert and Taylor & Francis, articles related to stress were sought out. Extra attention was given to information related to urban stress and its reduction. The effect of stress on cognitive maps was also investigated. In the end, 97 articles were reviewed for this paper.

2. What is Stress?

Stress is the body's natural reaction to a threat (Maslach, 2001)(Fig.1). Stress prepares the body to either flee from the threat or prepare to defend itself and this natural response helped our ancestors survive (Klingberg. & Larson S., 2001). Our ancestors relied on muscle strength, speed and agility. As a result, stress helped them by increasing muscle tone, heart rate, adrenaline, blood pressure, and cortisol. Stress also reduces melatonin and digestive function in preparation to either flee or fight (Maslach, 2001).

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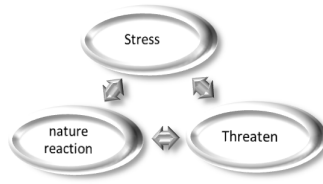


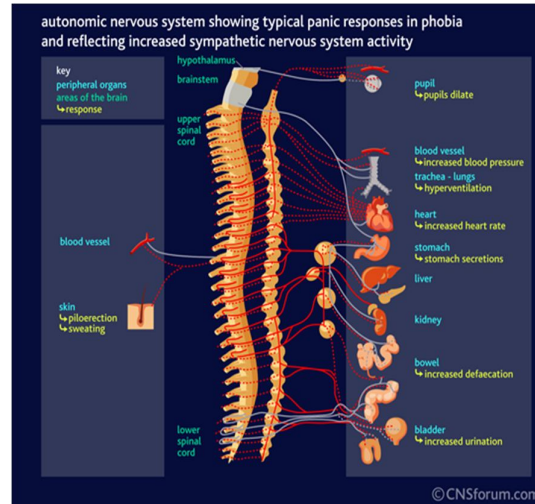
Figure1-relationship between stress, nature reaction and threaten

Stress can be beneficial in the short term but over the long term, it is harmful and cause serious illness if the body does not have a chance to rest (Atkinson & et al., 1996). Constantly high levels of muscle tone, sweating, heart rate, adrenaline and reduced melatonin levels results in imbalances, which can lead to feelings of helplessness and lack of control over one's life (Stigsdotter & Grahn, 2004). On a physical level, our reaction to danger is similar to our ancestor's reaction. If we are not careful, it can result in insomnia and muscle pain (Nystrom & Nystrom, 1995).

3. The effects of stress effects on the human body

Over the last few decades, stress has become the most important factor affecting diseases in modern societies (Nygren et al., 2002). In European countries, including Sweden, research has shown that the most common disease in patients from ages 20 to 60 years is stress and related illnesses (Grahn & Stigsdotter, 2003; Nygren et al., 2002).

The primary functions responsible for sustaining life, such as circulation and breathing, are governed by a Parasympathetic nervous system is connected to the "brain-brainstem". The Parasympathetic nervous system adapts and adjusts the internal environment of body in keeping with the external environment. This is an ongoing partnership where the central nervous system transmits information to the brain receives from the environment and the reactions of the Parasympathetic nervous system will make the necessary adaptations (Hasen, 1997).

Figure 2- Parasympathetic nervous system- Picture retrieved 28/3/2013 from: <http://www.cnsforum.com>

The emotional centers of the brain are directly connected to the Parasympathetic nervous system (Hasen, 1997). As a result, it must be acknowledged that rest is necessary to recover from the harmful effects of stress. If a balance can be reached between stressful activities and rest, "competence pleasure" can help guard against depression and the inability to cope (Havneskold & Risholm M. P., 1995; Maslach, 2001).

Stress can feel like someone is chasing you and you are too weak to flee. This feeling can have an effect on pulse, blood pressure, and the digestive system. In times of stress, reactant hormones are reduced and almost disappeared when the person is walking. If that person stands up, various stress hormones are combined and cause harmful effects to the whole body (Uvnas-Moberg, 1997) (Fig.2).

The devastating effects of stress are lessened through rest and sleep (Uvnas-Moberg, 1997). Although the effects of stress are difficult to control when they occur in a short time, a chance to rest can increase the ability

to cope with stress. Without the opportunity to rest and recover, the effects of stress can be fatal (Maslach, 2001)(Fig.3).

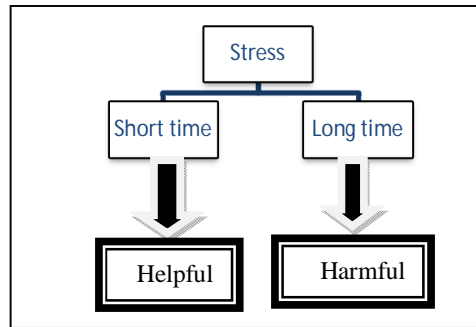


Figure3- relationship between stress and time

The ancient Greeks and Romans believed in the close relationship between the mind and the body (Gatchel, Baum, & Krantz, 1989). In other words, they saw physical health as the positive and idealistic expression of personal character. The relationship between the mind and the body has always been controversial. In terms of religious belief, health has played a significant role in the balance between man and his environment; as a result, health is the reflection of a meaningful and harmonious relationship with nature (Romanucci-Ross, Moerman, & Tancredi, 1997). In the twentieth century, the connection between health and nature can be seen in public health standards as planners in towns and cities work to alleviate common ailments including stress (Grahn & Stigsdotter, 2003).

Rene Descartes stated that the mind and body or logic and emotion, are separate. This system of belief was accepted for years by the scientific community. Now, however, questions have been raised regarding the accuracy of Descartes belief (Antonovsky, 1996). Research has shown that emotional experiences effect the body in a measurable fashion (Hansson, 1996). The human body is built to move throughout the day and to be exposed to daylight. These two factors support human health and increase the ability to cope with stress (Grahn & Stigsdotter, 2003).

4. Effect stress on the memory

Psychologist claim that over the long term, stress will effect memory (O. T. Wolf, 2009). The Freud himself hypothesized that trauma is associated memory suppression.



Figure4-relationship between Freudian hypothesis and way finding

Freud believed that trauma can arrest memory, and it can create wrong way finding and poor retrieval of memories (Fig.4). Studies that examined stress in older healthy subjects suggested that a stress induced cortisol. Increased levels of cortisol are associated with the poor retrieval of memories gained before the subject was exposure to stress. These studies stated that stress enhanced cortisol levels effected memory to the point that it was proven to be the reason for weak memory retrieval (S.J. Lupien et al., 1997; O.T. Wolf, Kudielka, Hellhammer, Hellhammer, & Kirschbaum, 1999) (Fig.5).

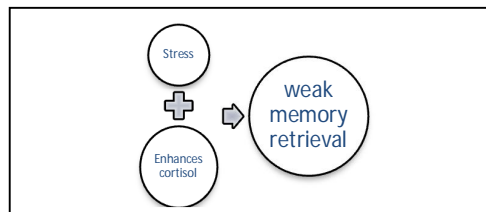


Figure5- The effect of stress on memory

Researchers have shown that in humans, cortisone causes “delayed memory retrieval” (D.J. de Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000) and stress creates decreased memory retrieval. (S.J. Lupien et al., 1997; O.T. Wolf et al., 1999). Also, these studies illustrated that stress or cortisol treatments decreased the efficiency of memory retrieval. In addition, stress and cortisol not only impacts memory on not only a quantitative basis but also on a qualitative basis (D.J. de Quervain et al., 2000; O. T. Wolf, 2009; O.T. Wolf et al., 1999). Research in this area has illustrated that stress and cortisol affects several memory processes (D.J. de Quervain, Aerni, Schelling, & Roozendaal, 2009) including the decreased “memory retrieval of emotional information”, but it may increase memory unity of “extinction training” (Bentz et al., 2013).

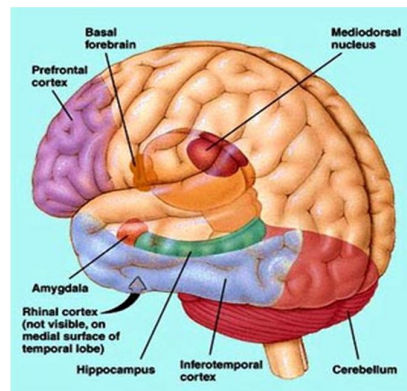
The results of the studies reviewed here clearly demonstrate that stress affects memory performance. There are several reason for this phenomena, for instance, “the nature of the stressor, the emotional arousal of the to-be-remembered material.” (Buchanan & Tranel, 2008). A stressor is a physical or psychological stimulus or event that threatens the homeostasis of the organism (Barsegyan & et al., 2010; E.R. de Kloet, 2005; Joe’s & al., 2008).

Other researchers have showed that stress can have a beneficially effect on memory consolidation (Andreano & Cahill, 2006; Cahill, Gorski, & Le, 2003; Roozendaal, 2000), prospective memory (Nater et al., 2006), and source memory (Smeets et al., 2006). Yet other researchers have stated that “memory retrieval tends to be impaired following a stressor” (Buchanan, Tranel, & Adolphs, 2006; D. J. de Quervain, Roozendaal, & McGaugh, 1998; Kuhlmann, Kirschbaum, & Wolf, 2005). These stressors result in corticosteroid release. The effects of corticosteroids released can result different cognitive performances because “corticosteroid receptors in the brain” are different (E. R. de Kloet, Oitzl, & Joels, 1999) (Table-1).

	Poor memory retrieval			Beneficially effect on memory		
	Topic	Year		Topic	Year	
Author	Weak memory retrieval	1997	1999	Consolidation	2000	2003 2006
		S.J. Lupien; S. gaudreau; B.M. Tchiteya; F. Maheu; S. Sharma; N.P. Nair; R.L. Hauger; B.S. Mc Eween; M.J. Meancy	O.T. Wolf; B.M. Kudielka; D.H. Hellhammer; C. Kirschbaum		B. Roozendaal	L. Cahill; L. Gorski; K. Le J.M. Andreano; L. Cahill
	Delayed memory retrieval	1998	2000 2005	Prospective	2006	
		D.J. de Quervain; B. Roozendaal; J.L. Mc Gaugh	D.J de Quervain; B. Roozendaal; R.M. Nitsch; J.L. Mc Gaugh; C. Hock		U.M Nater; U. Okere; R. Stallkamp; C. Moor; U. Ehler; M. Kliegel	
	Decreased memory retrieval	2006	2009	Source memory	2006	
		T.W. Buchanan; D. Tranel; R. Adolphs	O.T. Wolf; D.J. de Quervain; A. Aerni; G. Schelling; B. Roozenaal		T. Smeets; M. Jelicic; H. Merckelbach; M. Peters; A. Fett; J. Taverniers; C. Henguet; J. Dautzenberg	

Table.1- Researchers opinions about effect stress on memory

It is very difficult to give an accurate definition of a stressful situation. Some have defined it as being “made by the prefrontal cortex and limbic structures, in particular the hippocampus and the amygdale”, which connects recent events to past experiences. These areas of the brain are linked to “the hypothalamus, a central hub in the coordination of the physiological response to stress.” These situation can cause the “autonomic nervous system” to be activated and adrenaline and noradrenalin to be released from the adrenal medulla (Schwabe & Wolf, 2013) (Fig.6).



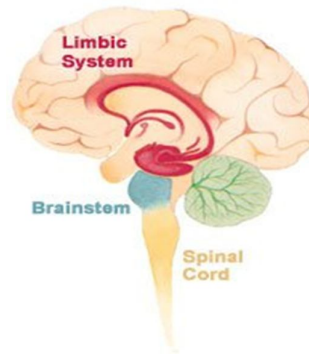


Figure 6- location of limbic system and cortex and Hippocampus- picture retrieved 28/3/2013 from: <http://blogs.unimelb.edu.au>

The hippocampus is especially sensitive to stress. The relationship between stress hormones and “hippocampal activity and hippocampus-dependent memory processes are well documented.” (Schwabe & Wolf, 2013). Stress can either increase or decrease hippocampal functioning depending on the duration of the stressor. Research has shown that “glucocorticoids at the time of long-term potentiation (LTP)” raised hippocampal LTP. After about an hour, genomic glucocorticoids activity was enhanced, in contrast to the glucocorticoids which reduced LTP in the hippocampus (Diamond & al., 2007; J. J. Kim & Diamond, 2002; Wiegert & al., 2006). Glucocorticoids are means through which steroid hormones are secreted from the adrenal cortex. The main glucocorticoids found in humans are cortisol. Through binding to membrane-bound and intracellular glucocorticoids and mineralocorticoid receptors (GR and MR, respectively), glucocorticoids result in rapid, non-genomic and slow, genomic effects (Schwabe & Wolf, 2013).

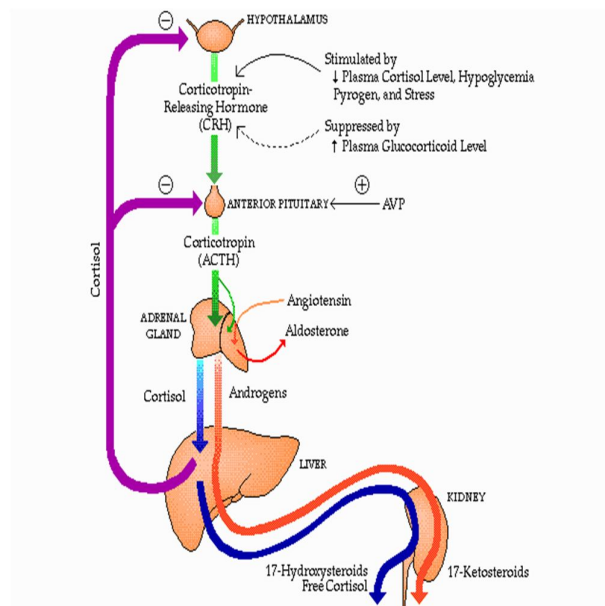


Figure.7- The hypothalamus operation and adrenal-function – Picture retrieved 28/3/2013 from: <http://www.renovemedspa.org>

5. Effect of green spaces on the urban stress

Health is the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (World, Health, & Organization, 1948). Based on this definition, a person who is not sick may not be healthy as health does depend on the positive condition of the whole individual in relation to their living situation (Stigsdotter & Grahn, 2004).

Biological (physical and psychological), cultural and social factors can influence the outcome of a disease (Qvarsell & Torell, 2001). Health gives life meaning, which is commonly described by individuals as living with joy, security and harmony (Hellqvist, 1999; Qvarsell, 1996) (Fig.8). If the definition of health is to be expanded, it is required that each individual's living environment must be examined (Stigsdotter & Grahn,

2004). For example, researchers state that humans react involuntarily to nature. They claim further that man-made artifacts such as houses and streets do not cause the same reactions (Ulrich, 1993).



Figure 8- health life meaning

Research shows that nature helps achieve balance and prevent misery (S. Kaplan, 1990) because nature has a calming effect on the human mind resulting in a reduction of fatigue (Ryan & Kaplan, 1998). Other studies have highlighted how nature can very quickly and effectively reduce the effects of stress. Therefore, natural environments, such as parks, gardens and green spaces can be very effective for reducing and eliminating stress (Herzog, Black, Fountaine, & Knotts, 1997; S. Kaplan & Talbot, 1983; Ulrich, 1984, 2001) (Fig.8). Also, exercise and exposure to daylight can reduce stress reactions (Kuller & Lindsten, 1992; Kuller & Wetterberg, 1996)(Fig.9). The evidences of recent studies shows that the relationship between people and nature is very important (Beatley, 2000; Crewe & Forsyth, 2011) especially in urban environments. Alberti (1999) illustrated conceptual forms that created a close relationship between nature and urban space (Crewe & Forsyth, 2011).

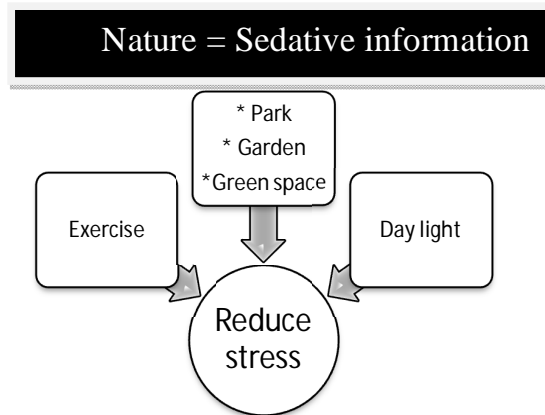


Figure 9- Natural factors affecting on stress reducing

Grahn and Stigsdotter in 2003 observed that in modern societies, stress and stress-related diseases is common. Their results showed that open green spaces reduced stress and had a great impact on the citizens of urban environments. These results explain why people who are depressed spend a lot of time out in the open green spaces (Grahn & Stigsdotter, 2003). Physical activity in natural environments (Barton & Pretty, 2010; de Vries, 2010), social contact (however informal or unplanned) in the green space (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003) and attractive environments for relaxing (Grahn, Ivarsson, Stigsdotter, & Bengtsson, 2010; R. Kaplan & Kaplan, 1989) are three behavioral mechanisms which decrease stress and promote wellbeing (Thompson et al., 2012) (Fig.10).

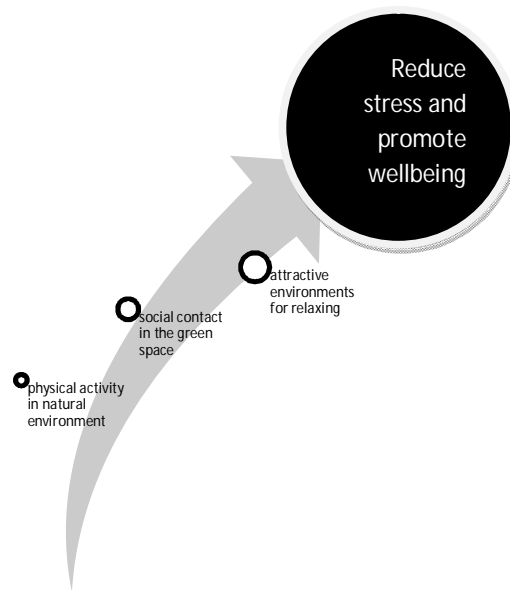


Figure10- three behavioral mechanisms which decrease stress and promote wellbeing

The physical environment around us can have a positive or negative impact on our lives (Rasmussen, 1986; Ulrich, 2001). As mentioned earlier, studies have shown that the human body involuntarily responds to natural elements in a positive and healthy way but artifact elements, such as residential or commercial towers and streets that are designed solely for cars do not have a positive impact on human health (Ulrich, 1984, 1993, 1999). Many researchers claim that with proper design, environments can be created that would take advantage of the restorative effects of the natural environment (Grahn & Stigsdotter, 2003; Stigsdotter & Grahn, 2004; Ulrich, 2001). Cultivating a relationship with nature helps people cope with stress and can be accomplished by creating easy to access green spaces for visiting and providing a space and time for rest and recovery. Urban and landscape design is beginning to focus on these issues for both indoor and outdoor spaces (Grahn & Stigsdotter, 2003) (Fig.11).

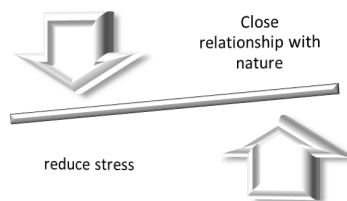


Figure11- The effect nature on stress

6. Nature and the power of restorative

A sense of security occurs when the whole body is in a state of perfect comfort. Kaplan and Talbot (1983) published an article discussing the tranquility of spending time in a natural environment (Talbot & Kaplan, 1983). They asserted that time spent in nature helped to restore health and vitality. A year later, Roger Ulrich announced that even having a window through which nature elements, such as a green space, has a positive impact on “post-operative”(Ulrich, 1984) patients. Researchers have suggested that nature and greenery are definitely catalyst for human health. Other findings have supported this statement (Hartig, Book, Garvill, Olsson, & Garling, 1996; Herzog et al., 1997; Ulrich, 1999, 2001).

There is another theory which states that modern humans are surrounded by a lot of information, which must be classified according to its importance (Hartig et al., 1996; R. Kaplan & Kaplan, 1989). The human brain reacts to information from the natural world by directing attention to messages originating from “our higher cognitive centers” and by becoming engrossed in the quiet. The natural environment contains too little information that must be classified and assessed (R. Kaplan & Kaplan, 1989). When the “higher cognitive center” is at rest the more primitive part of the brain is stimulated (Grahn & Stigsdotter, 2003).

7. Effect stress on cognitive function

For decades now, it has been said that stress affects memory performance. Some studies have shown that stress may change how multiple memory systems behave (Schwabe & Wolf, 2013). There are numerous studies that have shown the effects of stress on cognitive functions (S. J. Lupien & McEwen, 1997; Pruessner et al.,

2010) such as spatial memory (Schwabe et al., 2007). There are many other studies that illustrate the “multiple memory systems” of humans (Alvarez, Zola-Morgan, & Squire, 1995; McDonald & White, 1993, 1994; Milner, 2005; O’Keefe & Nadel, 1978; Packard, Hirsh, & White, 1989; Packard & McGaugh, 1996; Scoville & Milner, 1957; Squire & Zola-Morgan, 1991; Tulving, 1972).

The hippocampus is of these multiple memory systems and it helps with spatial memory. The caudate nucleus is another multiple memory systems and it is responsible of learning behavior and habits, especially “stimulus–response learning”. Both the hippocampus and the caudate nucleus can be used for navigating in an environment (Bohbot, Iaria, & Petrides, 2004; Hartley, Maguire, Spiers, & Burgess, 2003; Iaria, Petrides, Dagher, Pike, & Bohbot, 2003; Maguire et al., 1998; McDonald & White, 1993, 1994; Mizumori, Yeshenko, Gill, & Davis, 2004; Packard et al., 1989; Packard & McGaugh, 1996; Voermans et al., 2004). A spatial strategy is used by the hippocampus to construct a cognitive map of the environment (O’Keefe & Nadel, 1978).

Abundant research has illustrated that “stress to impair the hippocampus through the actions of glucocorticoids” (Conrad, Galea, Kuroda, & McEwen, 1996; Kleen, Sitomer, Killeen, & Conrad, 2006; McEwen & Sapolsky, 1995; McKittrick et al., 2000; Sapolsky, 1994; Sapolsky, Uno, Rebert, & Finch, 1990). As a result, an impaired hippocampus affects spatial navigation strategies. Chronic stress may prevent the formation of a cognitive map which is necessary for spatial learning (Bohbot, Gupta, Banner, & Dahmani, 2011; J. Kim et al., 2007).

Multiple cues can create a cognitive map with “hippocampus-dependent spatial memory system” for spatial navigation (Schwabe & Wolf, 2013). Spatial learning relies on the relationship between two or more stimuli in an environment in order to learn a route or the location of a target item. Studies show that the “hippocampus and prefrontal cortex are particularly sensitive to stress and stress hormones” (D.J. de Quervain & al., 2003; Oei & al., 2007) and stress damages cognitive systems (Schwabe & Wolf, 2013). Cognitive functioning can be destroyed by stress and it also increases fatigue (Cottrell & Barton, 2012; Reason, 1990). Stress raise the level of cognitive mistakes (Hockey, Nickel, Roberts, & Roberts, 2009; Lim et al., 2010) (Fig.9).

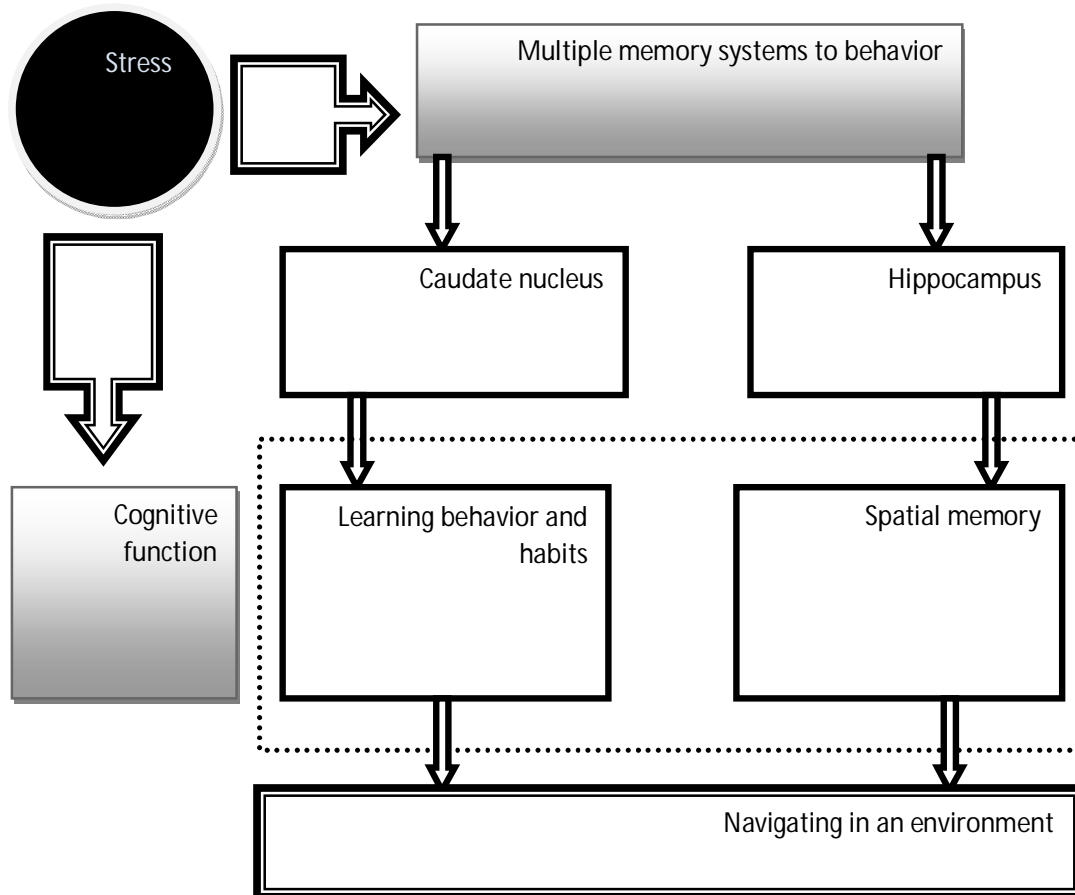


Figure12- relationship between stress and cognitive function

8. Conclusion

Stress is the natural reaction of a body threatened by danger. It is useful in the short time and harmful in the long term. Over a long period of time, it can create disease and illness in body and affect memory. There is a

Parasympathetic nervous system in the body that controls the living process. It adjusts the internal environment of body according to cues provided by the external environment, but it needs to rest in order to maintain balance. When there is continued, long term stress, this system will be out of balance.

There is close relationship between the mind and the body. Psychologists have stated that long term stress effects memory. In addition, stress enhances cortisol production, which also affects memory. In other word, stress and the subsequent increase in cortisol production is the reason for weak memory retrieval.

Health is a state of complete physical, social, and mental well-being that is associated with feelings of joy, security and harmony. Exercise, day light, parks, gardens and other green spaces can encourage feelings of joy and impact well-being. Stress is directly related to the relationship between people and their surrounding landscape. A natural environment positively impacts human health as well offering a level of protection against stress. For instance, seeing greenery reduces stress levels. The more green space available, the more effective its stress reducing capabilities.

Physical activity in natural environments, social contacts in green spaces and relaxing in attractive natural environments are three actives which reduce stress and promote wellbeing. Environmental behaviorists and psychologists have shown that designs base on nature reduce stress and increase the retrieval of memories. In contrast, artificial, man-made elements, such as residential or commercial towers and streets with heavy traffic can increase stress. A major focus for urban and landscape designers interested in encouraging rest and recovery is on access to natural environments in urban spaces.

Finally, stress affects cognitive function. Humans have multiple memory systems. For instance, the hippocampus is related to spatial memory and the caudate nucleus is related to learning behaviors and habits. Spatial memory, learning behaviors, and habits are components of cognitive function. The ability to navigate through space is positively impacted by reducing stress and improving cognitive function because it benefits both the hippocampus and caudate nucleus.

Suggestions for further research

Further research is needed to explore how other urban spaces can affect urban stress. One interesting issue open to further investigation is the effect of geometry on intelligibility and cognitive function. Another interesting question is what methods are available to urban designers to improve urban spaces so that they can reduce stress for urban inhabitants.

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