



Review article

Good daily habits during the early stages of life determine success throughout life[☆]



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ABSTRACT

This paper assesses hypothesis that sufficient sleep duration and proper circadian rhythms during the early stages of life are indispensable to a successful life. Successful life was defined according to the famous cohort studies of Mischel's and Dunedin. To assess the hypothesis, neuronal elements presumably affecting early daily habits and successful life are reviewed. The effect of sufficient sleep duration and proper circadian rhythms during early stages of life on the development of the prefrontal cortex has been found to be the key issue to verify the hypothesis. Socioeconomic status is found to be another issue to be studied.

1. Introduction

Insufficient sleep duration affects various brain functions [1] and is associated with behavioral, cognitive, physical, and developmental problems [2–5]. Physical, somatic and mental disturbances are also associated with circadian rhythm disturbances, such as shift work [6], jet lag [6] and social jet lag [7]. Short sleep duration during childhood has been reported to be associated with obesity in adults [8]. However, the long-term effects of unfavorable early daily habits (insufficient sleep duration and disrupted circadian rhythms during the early stages of life) on brain functions are not fully understood [9].

Poor daily habits of modern society (loss of physical contact, decreased physical activity, and short sleep duration with late bed and waking times) during the early stages of life are associated with truancy or dropping out of school, quitting employment, and committing suicide during subsequent years [10]. It has been suggested that deactivation of the serotonergic (5-hydroxytryptamine, 5-HT) system, the dorsal striatum, and the prefrontal cortex (PFC) are the candidate neuronal elements which relate the poor early daily habits with the subsequent unfavorable behaviors [9].

Self-control is known as a significant determinant of success throughout life, although it might be harmful to health by speeding the process of aging, especially for persons who were born into lower social classes [11]. Thus, socioeconomic status (SES) is assumed to affect early development through various elements. Although the famous longitudinal studies by the Mischel group [12–14] and the Dunedin study [15] revealed the association between early self-control and subsequent lives, they did not mention about SES. Anyway, the

former [12–14] identified factors to build better lives, such as higher academic scores, better social cognitive and emotional coping, higher educational achievement, higher sense of self-worth, better ability to cope with stress, less risky drug use, and lower body mass. The latter [15] identified good health, good wealth, and low crime outcomes. The current brief paper assesses hypothesis that sufficient sleep duration and proper circadian rhythms during the early stages of life (good early daily habits) are indispensable to having a subsequent adequate social life (successful life) (Fig. 1). However, it should be noted that large inter-individual differences are observed in preferred time of day for completion of distinct cognitive tasks, sleep timing, sleep duration and sleep structure [16], although humans are known to be diurnal animals [17]. Similarly, it is hard to define proper circadian rhythm, however, we now know that pre-industrial people awake just before sunrise and go to sleep 3.3 h after sunset [18]. An adequate social life (successful life) was defined according to the famous cohort studies of Mischel's and Dunedin [12–15] as a situation with presumable factors to build better lives. As mentioned before, these factors includes social cognitive and emotional coping, higher academic scores, higher educational achievement, higher sense of self-worth, better ability to cope with stress, lower body mass, good health, less risky drug use, low crime outcomes and good wealth.

To assess the hypothesis, neuronal elements presumably affecting early daily habits and successful life are reviewed. As such neuronal elements, 5-HT, oxytocin, the PFC and the ventral/dorsal striatum were selected with reference to previous studies [9]. Relationships among these elements are shown as numbered arrows in Fig. 1 and are evaluated in the following sections in numerical order. Through these

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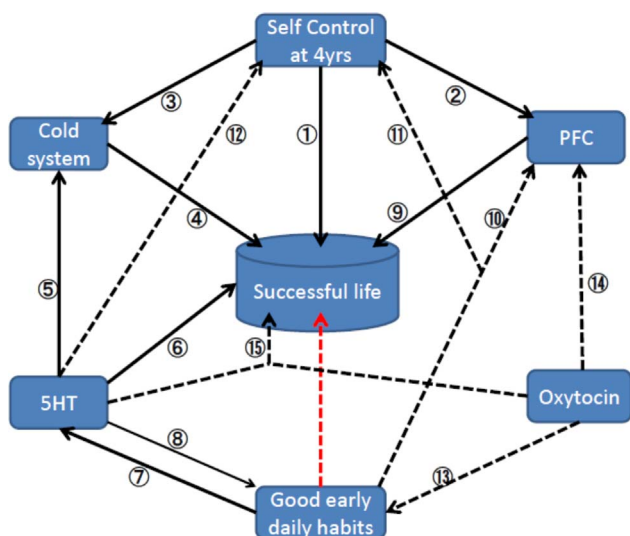


Fig. 1. Hypothesis and supported data. The red dotted arrow represents the current hypothesis that sufficient sleep duration and proper circadian rhythms during early stages of life are indispensable for an adequate social life. The numbered arrows from (1) to (15) represent the available data to support the hypothesis. Broad lines have evidence, whereas a thin arrow (8) has only weak evidence. Dotted arrows (10–15) need more studies to be confirmed. 5-HT; serotonin, PFC; prefrontal cortex.

analyses, the further and new study directions on the neuronal bases between the early stage of life and the subsequent one are expected to be found. It should also be noted that arrows do mean necessary requirements but not mean sufficient ones.

1.1. Arrow 1. Self-control at age four and successful life

The marshmallow test that Mischel and colleagues [14] developed in the 1960s assesses the ability of 4-year-old children to delay gratification. The children were given a choice between one reward (one marshmallow) that they could have immediately and a larger reward (two marshmallows) for which they would have to wait alone for up to 15 min [19]. Subsequently, it has been shown that this test has a significant predictive validity for social, cognitive, and mental health later in life [20], including higher educational achievement, higher sense of self-worth, better ability to cope with stress and less risky drug use [14]. Another large cohort study also showed that poor childhood self-control significantly predicted negative adult outcomes: worse health, more financial troubles, and more crimes committed [15]. It could be said that we have evidence in arrow 1 [14,15,19,20].

1.2. Arrows 2–5. PFC, the ventral/dorsal striatum (hot/cold system), 5-HT system and self-control at four years of aged

Casey et al. [21] revealed that children who were less able to delay gratification showed lower self-control in their forties (low delayers). They also showed higher activation in the PFC of high delayers when resisting temptation. In addition, they reported [21] higher activation of the ventral striatum in low delayers than in high delayers. Mischel termed the ventral and dorsal striatum as the hot and cold systems, respectively [14]. According to Caseys’ report [21], arrows 2 and 3 could be said to be supported by evidence [21]. Interestingly, a recent study revealed that patients with attention-deficit/hyperactivity disorder exhibited an increased response to reward receipt in the ventral striatum [22], although the underlying neuromechanisms of attention-deficit/hyperactivity disorder have not yet been determined [23].

Activity in the ventral striatum (hot system) correlates with short-term reward predictions, whereas activity in the dorsal striatum (cold system) correlates with long-term reward predictions [24]. Long-term reward is expected to bring good wealth and thus could be interpreted

as producing an adequate social life (successful life). Then, dominance of the cold system in comparison to the hot system could be interpreted as being advantageous for reward (good wealth), which could contribute to a successful life. It could be said that we have evidence in arrow 4 [24].

These correlations have been reported to be altered by 5-HT levels. An increase in small reward choices and the rate of discounting of delayed rewards have been reported when 5-HT was low [25], and the correlation between ventral striatum activity and short-term reward seeking was enhanced when 5-HT was low (achieved by dietary tryptophan depletion) [24]. Contrarily, the correlation between dorsal striatum activity and long-term reward seeking increased when 5-HT was high (achieved by dietary tryptophan loading) [24]. Arrow 5 could be construed as being supported by evidence [24,25].

1.3. Arrows 6–8. Good early daily habits, 5-HT system and a successful life

According to Arita [26], 5-HT neurons play a coordinating role for establishing a state that tends toward excitation, without directly acting on the muscles or the heart. In contrast, the person who has a 5-HT-deficient brain has poor awakening, poor standby of the autonomic nerves, a loose facial expression, weak posture, and a feeling of fatigue. Arita [26] also reported that these symptoms were seen in patients who have depressive disorders, poor anger management or with a loss of mental balance. Moreover, Arita [26] indicated that decreased activity of 5-HT neurons seems to underlie the pathologic condition of suicide [26]. Indeed, decreased 5-HT activity, especially in the PFC, is considered to play a significant role in suicidal behaviors [27,28]. In addition, an elevation of 5-HT is considered to be effective on several mental and/or psychiatric disorders [29]. Therefore, a 5-HT sufficient brain is considered to be necessary for a successful life, although direct evidence in arrow 6 has yet to be obtained. However, as mentioned earlier, the correlation between dorsal striatum activity and long-term reward seeking was greater when 5-HT was high [24]. Since long-term reward could be construed as meaning a successful life, it could be said that we have evidence in arrow 6 [24], albeit indirect.

The non-pharmacological ways to activate the 5-HT system that Young [30] proposed are: food (tryptophan-enriched diet), a positive (happy) mood, exposure to bright light and exercise. The 5-HT system is known to be activated by exposure to morning light [31] and rhythmic movements, such as one’s gait, chewing, and respiration [26,30,32]. According to the international classification of sleep disorders, version 3 [6], insufficient sleep leads to fatigue and malaise, which naturally results in poor physical activity. Insufficient sleep is disadvantageous for activation of the 5-HT system. Late bed times are often associated with decreased sleep duration [33] as well as increased opportunity for nocturnal light exposure, and late waking times that often reduce morning light exposure. Nocturnal light exposure inhibits melatonin secretion [34] and disrupts the circadian clock [35]. Reduced light exposure during the day time and in the morning [31] is disadvantageous for 5-HT activation [30]. Sufficient sleep duration and proper circadian rhythms (good daily habits), promoting morning sunlight exposure and sufficient physical activity, are considered to be necessary for activating the 5-HT system. An arrow 7 could be said to be true not only during childhood, but also during one’s entire life. An arrow 7 could be said to be supported by evidence [26,30]. Segawa [36] and Arita [26] emphasized that regular 5-HT activity that is established by age four to five or three to six, respectively, is important to obtain an adequate social life [9]. Taking these together, an activation of the 5-HT system that is achieved by sufficient sleep duration and proper circadian rhythms in these early years of life (good *early* daily habits) is considered to be important for a successful life. However, this history is represented by a red dotted arrow, which so far is unsupported by any direct evidence.

Factors that promote 5-HT activity, such as sufficient physical

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