Intrinsic and Extrinsic Influences of Self-regulation in Early Years of Life

Pimjuta Nimmapirat
Faculty of Psychology, Chulalongkorn University, Thailand
E-mail: pimjuta.n@gmail.com

Panrapee Suttiwan
Faculty of Psychology Chulalongkorn University, Thailand
Corresponding Author: E-mail: panrapee.s@chula.ac.th

Nancy Fiedler
Environmental and Occupational Health Sciences Institute, Rutgers University, USA.
E-mail: nfiedler@eohsi.rutgers.edu

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Abstract

This article provides information about the definition of self-regulation. The different terms that are relevant to self-regulation studies are reviewed, including delayed gratification, executive function, and self-control. The definitions of aspects of self-regulation are provided, such as emotion regulation, behavioral regulation, inhibitory control, and effortful control. The development trajectory of self-regulation is described from birth through childhood. Interesting intrinsic and extrinsic factors that influence children's development of self-regulation are provided, including temperament, neurodevelopment, toxic chemical exposure, maternal stress and depression, and parent-infant relationship. This article also suggests future research trends in studying the interplay effect between intrinsic and extrinsic factors on the development of child self-regulation.

Keywords: Self-Regulation, Temperament, Neurodevelopment, Toxic Chemical Exposure, Maternal Stress and Depression

Introduction

Self-regulation is an important factor for gaining successful life in many aspects, and a crowning achievement for early childhood (Berk, Mann & Ogan, 2006). Many studies found its association with better later academic achievement (Cambron et al., 2017; McClelland et al., 2007; Nota, Soresi & Zimmerman, 2004), and better health conditions such as less at risk to obesity, alcoholism, and risky sexual behavior (Heatherton & Wagner, 2011; Montroy, Bowles, Skibbe & Foster, 2014; Moffitt et al., 2011; Schlam, Wilson, Shoda, Mischel & Ayduk, 2013). On the other hand, the failure to regulate oneself can be a significant cause of several societal problems, such as addiction, aggressive and antisocial behavior, poor financial decisions, and substance abuse

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(Heatherton & Wagner, 2011; Wills, Walker, Mendoza & Ainette, 2006). Remarkably, it has been estimated that having poor behavioral self-regulation can be a cause of approximately 40% of deaths in the United States, mostly because of obesity and smoking (Heatherton & Wagner, 2011; Schroeder, 2007). Tangney, Baumeister & Boone (2004) mentioned that a high capacity and capability to regulate oneself should be robust, adaptive, and allow individuals to live happier, and healthier lives.

Self-regulation is a critical, relevant variable for an individual's successful and functional life; therefore, it is important to know what variables can influence the development of self-regulation, so the promotion and intervention can be developed appropriately and efficiently. This article aims to describe relevant information about self-regulation and to explore a big picture of self-regulation development trajectory that is influenced by intrinsic and extrinsic factors from prenatal through early child development.

Literature Review

Self-regulation definition and developmental trajectory

Self-regulation refers to an internal mechanism relevant to neurophysiologic, cognitive, and behavioral processes that enable the ability of individuals to regulate their own emotion, behavior, and cognition in a mindful, and goal-directed way (Bodrova & Leong, 2008; Kopp, 1982; Willoughby, Kupersmidt, Lee & Bryant, 2011).

The development of self-regulation starts from birth (Kopp, 1982) and continues developing through adolescence (Farley & Kim-Spoon, 2017). Kopp (1982) summarized that self-regulation is developed from the early month of life and will be developed into many forms of self-control depending on developmental stages. In the first three months, infants' regulation in this period mediates by neurophysiological maturation, parent interactions, and routines (feeding, sleeping, etc.). The next stage of self-regulation development is when infants turn 9-12 months, which self-regulation mediates by preference toward social behavior and quality of mother-child relationship. At this age, infants can respond to warning signals or simple verbal or non-verbal communication. In the second year of life, infants can understand more verbal signals, therefore, self-regulation in this period is mediated by maturational factors (e.g., growth of language), availability of means for tension reduction, parent sensitivity to child's needs, and attributes. After this second year period, the child will use more language skills to regulate themselves from the overt speech at 3 to 4 years and then covert speech around 6 years old. Lastly, from the preschool period onwards, children use more cognitive abilities, planning, and strategies to regulate themselves. Recent studies still support that self-regulation development is a bidirectional process of intrinsic, such as genetics, neurocognitive development, temperament, and physiological condition, and extrinsic influences, such as parent and child interaction, experience, and external environment (Frick et al., 2018; Kim & Kochanska, 2012).

Definition and terms that have been used to study self-regulation

Self-regulation has been studied since the 1960s. There are several variables that overlap with the construct of self-regulation (Frick et al., 2018), such as delayed gratification, executive function (EF), and self-control.

The earliest study in this area is delayed gratification, studied with preschool children (Mischel, 1961). The delayed gratification is to observe the outcome of children's self-regulatory processes, and strategies. Children need to control their impulses not to eat a snack immediately. They need to wait by themselves long enough

until the experimenter comes back to earn twice times reward. Children who have more capability and better strategies to regulate their impulses will result in a longer delay time (Mischel, Ebbesen & Zeiss, 1972).

The EF usually refers to a set of skills relevant to the prefrontal brain area which include cognitive flexibility, working memory, and inhibitory control. The construct of executive function reflects how individuals use their higher-order cognition to solve problems or learn new things (Raver & Blair, 2016). It could be stated that EF and self-regulation are relevant to each other (McClelland et al., 2014). EF helps individuals to have potential strategies to regulate themselves effectively in both emotional and behavioral aspects (Raver & Blair, 2016).

The definition of self-control is closest to self-regulation and some studies used this term referring to the same meaning (e.g., Baumeister, Schmeichel & Vohs, 2007). Diamond (2013) stated that self-control is a component of inhibitory control. Traditional definitions of self-control focus on effort and inhibition; however, the definitions of self-control have changed over time (Gillebaart, 2018). Generally, self-control seems to be a narrower concept than self-regulation, and does not include the emotional aspect unlike self-regulation; however, the distinct definition remains unclear.

In this article, the term, self-regulation, will be used to illustrate the broad aspects of the ability that children use to modulate emotional reactivity, and behavioral response to physiological arousal, needs, and impulsivity. According to the definition of self-regulation, diverse sets of perspectives of self-regulation have been studied, such as emotion regulation, behavioral regulation, inhibitory control, and effortful control. (e.g., Calkins & Fox, 2002; Eisenberg et al., 2010; Joyce et al., 2016; Kochanska, Coy & Murray, 2001; Little & Carter, 2005; Ponitz, McClelland, Matthews & Morrison, 2009; Tominey & McClelland, 2011). Each aspect has its meaning.

Emotion regulation refers to mechanisms, behaviors, skills, and strategies, whether automatic or effortful that modulate, inhibit, maintain, or enhance the intensity and valence of emotional experiences, and expression, in pursuit of an affective equilibrium or homeostasis (Calkins & Hill, 2007; Taipale, 2016).

Behavioral regulation is the integration of cognitive skills, including attention, working memory, and inhibition to express an appropriate overt behavior (Blair, 2002; McClelland et al., 2007). For example, behavioral regulation skills enable children to pay attention to a teacher's instruction, remember new rules, and inhibit inappropriate behavior or impulsive response according to the rules. The behavioral aspect of self-regulation is usually studied in preschool children as an indicator of readiness for the behaviors for school success (e.g., McClelland et al., 2014; Moriguchi & Hiraki, 2011; Tominey & McClelland, 2011; Wanless et al., 2011). Because children at this age start to develop strategies to control their behavior due to their prefrontal brain area development (Moriguchi & Hiraki, 2011; Raver & Blair, 2016). Many studies in several cultures found that behavioral regulation is associated with academic achievement (McClelland et al., 2014; Schmitt, McClelland, Tominey & Acock, 2015; Von Suchodoletz et al., 2013; Wanless et al., 2011)

Inhibitory control refers to the cognitive ability that enables children to inhibit, and control attention, behavior, thoughts, and emotions to overcome their inappropriate habits and/or impulses (Diamond, 2013). Inhibitory control seems relevant to the "Don't" aspect of self-regulation (see Kochanska et al., 2001). Research suggests that inhibitory control becomes observable in the second year of life (Kochanska et al., 2001).

Effortful control refers to abilities to focus attention, to force children to do something necessary but unpleasant, to detect errors, to engage in planning, and to suppress a dominant response and perform a subdominant

response (Eisenberg, 2012; Kim & Kochanska, 2012; Rothbart, Ellis, Rueda & Posner, 2004). Effortful control seems relevant to the "Do" aspect of self-regulation (see Kochanska et al., 2001).

Intrinsic influences of self-regulation

Temperament: Temperament is a fundamental of children's emotional reactions and regulation to their physiological conditions and to the external environment that is related to their behavior and is influenced by both biological factors and environmental factors (Shiner et al., 2012). Emotional reactions can be positive or negative, and the reaction to the same stimulus can be different in each person (Kagan, 2013; Rothbart & Jones, 1998).

Self-regulation is a part of children's temperament and is often referred to as effortful control. For example, Rothbart, Ahadi, Hershey & Fisher (2001) identified three broad components of temperament, including effortful control, surgency/extraversion, and negative emotionality. Effortful control helps children in regulating negative emotional reactivity, attentional control ability to such as gaze aversion, or selective orienting (Rothbart, Posner & Kieras, 2006). At a very young age, the adult plays an important role in distracting the child from discomfort, but when children grow up, they will develop their own means to distract themselves from a distressing stimulus (Kochanska et al., 2001; Rothbart et al., 2006). A link between children's temperament and later self-regulation seems to be moderated by parent-child interaction. For instance, Kim & Kochanska (2012) found that highly negative emotional infants at 7 months old showed less self-regulation 18 months later when they were in unresponsive relationships. However, highly negative emotional infants at 7 months old who were raised by responsive mothers were more self-regulated. Therefore, children with difficult temperaments may need more help from an adult, especially the significant caregiver of the child, to diminish and cope with their negative emotions.

In conclusion, temperament is the fundamental characteristic of emotional reactivity. Individual differences in temperament have been found to be associated with children's self-regulation. Reciprocally, children whose temperaments are difficult may need more help to regulate their emotions. The way parent responds to their child's temperament also impacts the child's experience of the external regulatory process that continually effects later self-regulated strategies.

Neurodevelopment: Neurobiological models propose a vertical-integrative hierarchical system of the regulatory process, which includes the cohesion of three brain systems: the brainstem, limbic, and cortical systems (see Geva & Feldman, 2008). Primarily, the brainstem system plays the role of how newborns react to internal and external conditions. The brainstem system develops rapidly from the third trimester (Lo et al., 2017). It is related to automatic, and physiological regulation, such as vagal regulation, and sleep cycles, that provide the physiological underpinning of the regulation of state, attention, temperament, and maintain homeostasis. Damage in the brainstem area causes infants to have difficulties with physiological regulation, such as sleep, feeding, or self-soothing (Geva & Feldman, 2008) and may cause difficulties in later development of behavioral inhibition of negative affect when experiencing stressful situations (Geva, Schreiber, Caspi & Shiffman, 2014). Secondly, the limbic system becomes more mature after 3 months, including the ability to recognize reward or threat, which leads to positive affect, such as joy or negative affect such as fear or distress. Additionally, it is relevant to the development of early attention and emotional responsiveness in infants (Geva & Feldman, 2008). The anterior cingulate cortex (ACC) has been found as a key to attention, emotional reactivity and

regulation, and goal-directed behaviors in the limbic system. For instance, Casey et al. (1997) found that children aged 5-16, who had larger right anterior cingulate, performed faster reaction time and more accuracy when doing a task that required predominantly controlled processes.

Lastly, the cortical system is related to higher-order brain function, logical reasoning, effective planning, attention control, working memory, and inhibitory control, which are essential for self-regulation. Research suggested that children who have more activation in the prefrontal area can perform better in these skills. For example, Moriguchi & Hiraki (2011) conducted longitudinal research observing children at 3 and 4 years of age. This research used near-infrared spectroscopy (NIRS) as a method to assess the level of prefrontal activation in 3-year-old children for collecting data both Time 1 and Time 2, while they were playing a dimensional change card sort (DCCS) which is an attention control task. The result of this study found that the children who could not pass the task correctly at age 3 had less activation particularly in the prefrontal cortex. If they could perform it correctly at age 4, they had more activation in the prefrontal cortex comparing to the activation in the previous age. Furthermore, overall children at age 4 had significantly greater prefrontal activation than at age 3. In conclusion, brain development plays an essential role in self-regulated behaviors, starting from birth. Differences in size or activation in the brain areas cause individual differences in performing and mastering self-regulation abilities.

Extrinsic influences

Toxic chemical exposure: Several epidemiological studies have been found that neurotoxicants, such as organophosphates (OPs), air pollution, lead, alcohol, and tobacco, can impair children's neurological and behavioral development. OPs which are commonly used insecticides in agriculture (Panuwet et al., 2012), have been shown to adversely affect attention, and mental development among children exposed prenatally (Eskenazi et al., 2007; Marks et al., 2010; Rauh et al., 2012). Additionally, Rauh et al. (2012) found inward deformations in the dorsal and medial surfaces of the left superior frontal gyrus, a region supporting higher-order cognitive functioning, including executive function which is relevant to the self-regulated abilities and strategies. Air pollution has been found to associate with deficits of cognitive functions, including executive function and self-regulation (D'Angiulli, 2018; Margolis et al., 2021). Margolis et al. (2016) found that prenatal exposure to air pollutants, polycyclic aromatic hydrocarbon, is associated with deficient emotional self-regulation across early and middle childhood. Research also found that air pollution can damage several brain areas and can cause cognitive deficits (e.g., Calderón-Garcidueñas et al., 2016). Davis et al. (2004) found that children who were lead-exposed demonstrated less self-regulated attention than the non-exposed group. Prenatal opioid, alcohol, and tobacco exposure have been found to associate with lower self-regulation, compared to non-exposed children (Beauchamp et al., 2020; Froggatt et al., 2020; Wiebe et al., 2015). These epidemiological studies suggest the same idea that neurotoxicant exposure to children, even in prenatal, can be harmful to children's cognitive development which is relevant to self-regulation.

Maternal stress and depression: Maternal negative mood, from both prenatal and postnatal periods, has been found to correlate with the child's ability to self-regulate. (Bush et al., 2017; McQuillan & Bates, 2017; Neuenschwander & Oberlander, 2017). Bush et al. (2017) found that higher maternal prenatal and postnatal perceived stress could predict lower surgency and self-regulation. Stressed parents tend to be more hostile in response to their child which can result in abusive behavior and child neglect, which causes the child to develop

negative adjustment outcomes (McQuillan & Bates, 2017). On the same hand, maternal depression, both prenatal, and postnatal is also relevant to children's neurobehavior and development of self-regulation (Field, 2011). Additionally, the depressed mother is likely to be detached and insensitive to the child's signals and consequently fails to provide appropriate and contingent stimulation to facilitate the development of emotional regulation (Feldman, Eidelman & Rotenberg, 2004). For instance, Maughan, Cicchetti, Toth & Rogosch (2007) found that child's early experience in maternal depressive behavior predicted later children's dysregulated emotion patterns.

Parent-infant relationship: Many researchers found a significant association between mother-child interaction on self-regulation. Bernier, Carlson & Whipple (2010) studied relations between maternal sensitivity (appropriate and consistent responses to infants' signals), maternal autonomy support (supporting children's goals, choices, and sense of will), and maternal mind-mindedness (to use mental terms while talking to the child) to the child's later development of EF. They found maternal autonomy support, measured at aged 12 months, has the strongest association with later inhibitory control, in which a component of EF, at 26 months. In addition, Cheng, Lu, Archer & Wang (2017) found that, in Chinese samples, maternal mind-mindedness predicted inhibitory control of children aged 25 months and 38 months. Likewise, maternal mind-mindedness and maternal autonomy predicted performance on delay tasks at 38 months. Maternal hostility has been associated with children's behavioral and emotional regulation due to children's experience of a hostile environment and internalization of inappropriate strategies to modulate impulse and emotion (Scaramella & Leve, 2004). These findings suggest the important of adult role to facilitate children's development of self-regulated skills. Van Aken, Junger, Verhoeven, Van Aken & Dekovic (2007) found that for temperamentally difficult children were more vulnerable to maternal negative control and lack of maternal sensitivity which might result in higher externalizing problem behaviors, such as more impulsivity, non-compliance, and oppositional behaviors, than those with less difficult temperament. The finding suggests that children's specific temperament can also play an important role in an association between parent-child interaction and children's self-regulatory behaviors.

Conclusion & Discussion

Several studies have found the impact of intrinsic and extrinsic factors that influence the development of self-regulation. Nature and nurture have complex interactions in every period of life that shape the way children develop self-regulated abilities. For example, extrinsic factors during prenatal development, such as neurotoxicant exposures, substance use, and maternal stress may alter in utero neurodevelopment. In the postnatal period early months of life, newborns have their own temperament which is associated reciprocally with their self-regulated abilities. Maternal sensitivity, structuring, appropriate response, and non-hostile response to children's needs also effect children's gaining effective strategies to modulate and cope with negative affect and impulsivity. Further investigations on the interplay between intrinsic and extrinsic factors that associate with the development of child self-regulation, from prenatal to later years in life, will provide a clearer picture of the relevant influences of self-regulation at each developmental age. In addition, the clearer picture would benefit the policymakers, teachers, and practitioners who work with children and families in designing preventive practices and proactively providing relevant environmental factors that help our children

develop better self-regulation. Therefore, it is important that future research needs to investigate the interplay between intrinsic and extrinsic factors that affect the development of children's self-regulation.

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