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Learning to control through culture: Explaining variation in the development of self-regulation

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Abstract

Self-regulation is a goal-directed behavior involving adaptive decision-making. It consists of multiple cognitive and motor skills, is shaped by complex sociocultural environments, and has short and long-term consequences for child outcomes. Yet most of what we know about the development of self-regulation comes from research conducted among communities that are unrepresentative of most of the global population. To fully understand the complexities of the development of self-regulation requires globally representative data on the diverse and complex cultural environments in which children learn. Our objective is to highlight discoveries about how complex cultural influences shape the development of self-regulation. We discuss the impact of child-rearing environments, educational influences, and environmental stressors on the development of self-regulation based on research conducted with populations worldwide. We provide empirically based recommendations for measuring self-regulation in context. Our conclusion includes suggestions for future research to promote efforts to build a globally representative science of self-regulation.

Keywords: Self-regulation, executive functions, cross-cultural comparison, cognitive development, social development, cultural learning

Learning to control through culture: Explaining variation in the development of self-regulation

"Only those who try to resist temptation, know how strong it is." - C. S Lewis, 1952.

Self-regulation is defined by cognitive, developmental, and educational scientists as a goal-directed behavior involving adaptive decision-making (Kidd et al., 2013; McClelland et al., 2015). It is typically studied using tasks that require individuals to override and manage impulsive actions through controlling or directing behavior(s) (Hofmann et al., 2012; McClelland & Cameron, 2012; Montroy et al., 2016; Mora & Ozakinci, 2013). According to this model of self-regulation, an individual must keep an end goal in mind while simultaneously controlling and coordinating behavior toward achieving it (Kelley et al., 2015).

Multiple complex cognitive processes, including executive functions (EFs) such as response inhibition or self-control (i.e., resisting temptations and resisting acting impulsively), interference control (i.e., selective attention and cognitive inhibition), working memory (i.e., short term memory involved in the manipulation of information), and cognitive flexibility or shifting (i.e., quickly and flexibly adapting to changed circumstances and seeing anything from different perspectives) (Diamond, 2013) as well as planning, reasoning, and motor control, underpin a child's emerging ability to regulate their behavior (Cook et al., 2019; Doebel, 2020; Fay-Stammbach et al., 2014; Miyake et al., 2000; Miyake & Friedman, 2012; Modrek & Wolf, 2024). There is a lack of consensus in the field about the number of factors in EF; the number is largely dependent on the experimental methods utilised, the age of the sample, and reflects difficulty in getting reliable measurements of individual EFs (Best & Miller, 2010; Diamond, 2013; Doebel, 2020; Miyake & Friedman, 2012; Spaniol & Danielsson, 2021; Zelazo & Carlson, 2012). There is

consensus however, that self-regulation requires cognitive flexibility and attentional control (sometimes used interchangeably) to focus on the end goal and plan the steps to achieve it (Rueda et al., 2005). Working memory is required to keep a goal in mind while also considering, planning, and processing the necessary steps to achieve it (Hofmann et al., 2012). Inhibition is needed to override incompatible or irrelevant behaviors to reach their intended goal (Montroy et al., 2016). Reasoning is required to consider different kinds of information and decide whether to inhibit a particular behavior (Téglás et al., 2011). For successful self-regulation, gross and fine motor skills are also required (McClelland et al., 2015; Willoughby & Hudson, 2023).

The ontogenetic development of self-regulation is a product of neurological maturation, learning, and socialization (Bernier et al., 2010; Chevalier et al., 2022; Wesarg-Menzel et al., 2023). Throughout development, children become increasingly capable of controlling their cognition, emotion, and behavior (Baker & Perry, 2022; Diamond, 2002; Hartung et al., 2020; Lyons & Zelazo, 2011; Montroy et al., 2016; Ponitz et al., 2008). Postnatal cognitive and neurological maturation, particularly the prefrontal cortex, underlies the progression from stimulus-based responses to deliberate behaviors and controlled thoughts (Casey et al., 2000; Diamond, 2002; Engelhardt et al., 2019; Farah et al., 2006; Tecwyn et al., 2014). Infants practice self-regulation within the first few months of life by self-soothing, and between the ages of 12-18 months, self-soothing behaviors, such as thumb sucking, emerge (Lyons & Zelazo, 2011). In early life, children depend on their caregivers for physical and emotional support and external regulation (Topham et al., 2010). Self-regulatory behaviors continue to develop through early to middle childhood, a critical developmental period characterized by high neural plasticity (Sankalaite et al., 2021). However, self-regulation development is protracted and continues to develop through adolescence and early adulthood as individuals reach cognitive maturity (Best & Miller, 2010).

Measuring self-regulation

The language describing the higher-order cognitive processes detailed above reflects constructs of control, which has had profound implications for the kind of cognitive tasks designed to study the development of self-regulation (McClelland & Cameron, 2012; Zelazo, 2006). To empirically measure self-regulation, experimenters use behavioral tasks to examine internal regulation, such as delay of gratification, inhibition, working memory, or cognitive flexibility tasks (Nachón et al., 2020; Steinbeis, 2023). In addition to cognitive performance tasks, researchers commonly solicit caregiver and teacher ratings of children's regulatory behaviors using questionnaires or observational measures (see Nachón et al., 2020 for a meta-analysis of the different methods used to test self-regulation). Measuring performance on these tasks has been informative in providing evidence for a link between childhood self-regulatory performance and later life success and outcomes (Robson et al., 2020), particularly academic achievement (Stucke & Doebel, 2023). However, research examining relations between self-regulation and child outcomes such as academic achievement has, until relatively recently, primarily included only children from High-Income Countries (HIC; Obradović et al., 2022; Obradovic & Willoughby, 2019) and Western Educated, Industrialized, Rich, and Democratic (WEIRD; Henrich et al., 2010) populations. There is a growing consensus that the scientific community needs culturally sensitive measures to examine global diversity in the development of self-regulation as well as the development of psychological constructs more generally (Arafat et al., 2020; Hruschka et al., 2018a; Jukes et al., 2024; Jukes et al., 2018a; Kline et al., 2018; Obradovic & Willoughby, 2019; Zuilkowski et al., 2016). As Burger and colleagues (2023, pp. 565) note, the field traditionally reflects “WEIRD researchers conducting WEIRD science with WEIRD participants, using WEIRD protocols.”

In addition to longstanding biases to primarily studying children in HIC populations, most of the research that uses behavioral tasks of self-regulation does not examine the impact of cultural context(s) in childrearing and educational practices, task design, environmental influences, underlying researcher biases, or conceptual differences across tasks (Jukes et al., 2024; Obradović et al., 2022). For example, recent research by Yanaoka and colleagues (2022) demonstrates the importance of considering cultural norms when comparing delays in gratification in Japanese and American children. Japanese and American children demonstrated different waiting times when the reward was food versus a gift—a notable reflection of different cultural norms in these countries. Understanding the cultural assumptions and interpretations inherent in many cognitive tasks is critical to accurately documenting and explaining the sources of variation in self-regulation worldwide (Obradović et al., 2024). Globally representative data generated by culturally sensitive measures will allow the scientific community to gain a more comprehensive understanding of variation in self-regulatory behavior based on an individual's environment, experience, culture, and situational demands (Fawcett et al., 2012; Nachón et al., 2020; Schmitt et al., 2019).

This paper aims to highlight discoveries about how complex cultural influences shape the development of self-regulation with research with globally representative populations. We first discuss the impact of variation in childrearing environments, educational influences, and environmental stressors on the development of self-regulation based on research conducted with populations worldwide. We then provide empirically based recommendations for measuring self-regulation in context. Finally, we end with some suggestions for future research to build a globally representative science of the development of self-regulation.

Cultural considerations in studying self-regulation

The development of self-regulation is a product of the interaction of biology and culture (Legare, 2019). Here, we define culture as the cumulative effects of shared knowledge on behavior (Laland, 2017). A broad and complex range of beliefs, knowledge, skills, values, norms, traits, emotions, and cognitive processes work in concert to guide and shape an individual's behavior (Legare, 2017; Super & Harkness, 1986). Explaining the development of self-regulation requires global representative research on the diverse and complex cultural ecologies children inhabit. To accomplish this, we must go beyond the typical reliance on findings from WEIRD populations towards a globally representative science of regulation (Nielsen et al., 2017).

Recent research with globally diverse populations of children has revealed evidence for the impact of sociocultural contexts on the development of self-regulation and related constructs such as EFs (Bayley, 2022; 2024; Cook et al., 2022; Feldman et al., 2006; Gestsdottir et al., 2014; Ivrendi, 2011; Jamali Paghale et al., 2018; Keller et al., 2004; Koomen et al., 2020; Lamm et al., 2018; Lan et al., 2011; LeCuyer & Zhang, 2015; Ma et al., 2018; McCoy et al., 2017; Modrek & Wolf, 2024; Munakata et al., 2020; Nemati et al., 2023; Nketia et al., 2024; Obradović et al., 2022; Schmitt et al., 2019; Segura et al., 2024; Sun & Tang, 2017; Von Suchodoletz et al., 2015; Wanless et al., 2011a; Wanless et al, 2011b; Yu et al., 2016). Collectively, this research reveals cultural variation in the development of self-regulation. Rather than a clear difference within and between certain cultures, variation reflects cultural, educational, social, and environmental influences (Munakata & Michaelson, 2021; Steinbeis, 2023). Individual traits, cultural norms, life experiences, and environmental context influence how children use self-regulation adaptively to achieve specific goals (Holochwost et al., 2023).

Given the substantial cultural variation in the learning contexts of childhood, the developmental course of self-regulation is not linear or universal (McClelland & Cameron, 2012;

Montroy et al., 2016; Wanless et al., 2016). Instead, a growing body of globally representative data illustrate that cultural factors impact the development of self-regulation both directly and indirectly through exposure to others (Baker & Perry, 2022; Munakata & Michaelson, 2021). For example, cross-cultural differences in parenting style, socialization practices, classroom practices, family structure, and environmental stressors impact the developmental trajectory of self-regulation (Cabrera et al., 2014; Keller et al., 2004; Kiss et al., 2014; Koomen et al., 2020; Lamm et al., 2018; Lan et al., 2009; Ma et al., 2018; Li & Lau, 2019; Mihret, 2019; Nemati et al., 2023).

Childrearing Environment

A child's immediate family is at the core of proximal factors impacting self-regulation (Williams & Howard, 2020). From birth, infants rely on their caregivers to learn how to navigate the world around them, from learning the local language to the expectations and norms of their community (Legare, 2019). As children's cognition develops and autonomy increases, caregivers play a critical role in supporting self-regulatory behavior through their levels of responsiveness and warmth (e.g., parenting style) and support (e.g., scaffolding) (Koşkulu-Sancar et al., 2023; Samdan et al., 2020).

Childrearing allows for the formation of culturally distinctive adults (Quinn, 2005). Parents transmit cultural values, attitudes, and goals to children throughout their development (Morrison et al., 2010; Spera, 2005) such that caregiving reflects culture (Arafat et al., 2020; Jukes et al., 2021). For example, Sri Lankan Tamil families prioritize the collective (family) over individuals (Subaskaran & Balasuriya, 2017). Japanese mothers promote closeness between themselves and their child from a young age, while independence in children is encouraged in American cultures (Bornstein et al., 2012). Pakistani families prioritize obedience in young children (Batool, 2013), Tanzanian parents prioritize emotional regulation (Jukes et al., 2021), and Chinese parents focus

on training children (Lin & Fu, 1990). Thus, the parenting style, practices, and beliefs caregivers adopt provide the first source of cultural variation within the childrearing environment, which shapes the emergence of self-regulation and its selective expression later in development (Bornstein, 2012; Cumming et al., 2022; Díaz & McClelland, 2017; Jaramillo et al., 2017; Morrison et al., 2010; Patock-Peckham et al., 2001; Shaffer & Obradović, 2017).

Traditional scholarship on parenting styles is primarily based on research with Euro-American families (White, high- to middle-SES) and historically has lacked sufficient consideration of cultural factors and differences in socialization practices and values despite often being applied to very dissimilar cultural contexts (LeCuyer & Swanson, 2017; Lipina, 2021). Until recently, most research has also only assessed maternal parenting styles (Fay-Stammbach et al., 2014; Karreman et al., 2006; Zelazo, 2013).

Research on parenting conducted primarily with Western populations has documented four parenting styles (Cobb-Clark et al., 2019; Kuppens & Ceulemans, 2019). Permissive parenting entails accepting a child's actions and desires while avoiding exerting control or power. Authoritarian parenting consists of controlling, shaping, and evaluating a child's attitudes to a set standard. Authoritative parenting involves directing the child's behavior and controlling when the child diverges. Neglectful parenting is characterized by a lack of engagement, reflecting low control and support. With such notable ties to control, parenting styles impact children's self-regulation differently. While children of neglectful parents tend to perform less well on measures of self-regulation, children who have experienced a permissive or indulgent parenting style show more mixed results (Kuppens & Ceulemans, 2019; Lamborn et al., 1991; Steinberg et al., 1994). Children who experience authoritative parenting demonstrate higher self-regulation levels; in contrast, authoritarian parenting may undermine the development of self-regulation, at least among

White, middle-class families (Grolnick & Ryan, 1989; Huang & Prochner, 2003; Lamm et al., 2018; Patock-Peckham et al., 2001). There is mounting evidence, even within Western countries, for ethnic, gender, and age variation in the number and type of parenting styles and their effects on the development of self-regulation (Domènech Rodriguez et al., 2009; LeCuyer et al., 2011).

Research examining cross-cultural variation in parenting styles has begun to provide novel insight into the global diversity of caregiving practices and their influence on self-regulation (Arafat et al., 2020; Tamis-LeMonda et al., 2008). Studies conducted in Western populations have documented relations between improved self-regulatory performance and authoritative parenting styles. There is also evidence for this relationship in non-Western countries. For example, authoritative parenting in Iran is positively associated with academic achievement through increased self-regulated learning and the involvement of parents in pre-adolescent girls (Amani et al., 2020). There are notable exceptions, however. Although authoritarian parenting is typically predictive of poorer school achievement in European American children (Chao, 1994), this is not the case for Chinese children who regularly score highly on self-regulation and EF tasks (Lan et al., 2011; Oh & Lewis, 2008; Sabbagh et al., 2006; Schmitt et al., 2019; Tran et al., 2019). In addition, in non-Western countries such as Kenya and Cameroon, authoritarian parenting predicts greater self-regulatory capacities than Western populations in Germany that practice authoritative parenting styles (Koomen et al., 2020; Lamm et al., 2018). Rather than looking at authoritarian parents from a control perspective, considering culturally appropriate scaffolding and the kinds of regulatory abilities parents value may be more suitable (Baker & Perry, 2022). By applying classifications of parenting styles developed in Western contexts, researchers have also applied Western cultural values and norms, which may not accurately characterize non-Western parenting practices and childrearing norms (Arafat et al., 2020; Baker & Perry, 2022). Future research would

benefit from using a combination of methods to measure parenting style, learning more about individual cultures to understand how parenting practices are perceived, and departing from the incorrect assumption that one parenting practice is tied to universal constructs (Amani et al., 2020; Baker & Perry, 2022; Tamis-LeMonda et al., 2008).

Beyond parenting styles, culturally-specific orientations towards autonomy and relatedness influence child behavior and may shape the developmental pathway of self-regulation early in ontogeny (Amani et al., 2020; Keller & Kärtner, 2013; Keller et al., 2004; Koomen et al., 2020). Nurturing, scaffolding, and stable relationships with caregivers support the development of self-regulation (Keller et al., 2004; Lamm et al., 2018) and EFs (Koşkulu-Sancar et al., 2023) which may be particularly impactful during early childhood (Valcan et al., 2018). A meta-analysis of studies conducted in Western cultures (Europe, Australia, and New Zealand) revealed that out of the 41 studies, 2-5-year-old children have higher levels of self-regulation when their parents use positive control through encouragement, teaching, and guidance. In contrast, children with parents who use more controlling strategies have lower levels of self-regulation (Karreman et al., 2006). Further research on the impact of positive and negative control and parental responsiveness on children's self-regulation in more diverse populations is required.

There is cultural variation in parental support for practices that have the potential to promote the development of self-regulation. For example, symbolic play, in which children use pretense to learn about what is imagined and real, supports the development of children’s self-regulatory abilities (Foley, 2017). Play allows young children to strengthen self-regulatory skills and interact with individuals from different upbringings, thus giving them ample opportunities to refine and develop their skills and learn about rules and roles (Foley, 2017; Legare, 2019). There is variation within and between cultures in attitudes towards play and the amount and type of play

that children are permitted to engage in (Lyu et al., 2023). While parents and teachers from some communities do not prioritize play, others encourage children to engage in structured and unstructured play (Christie, 2022). These differences are significant, as play benefits cognitive, social, and physical development (Singer et al., 2006), including a potential relationship between physical activity and self-regulation (Cook et al., 2021). Considering cultural differences in attitudes and norms towards behaviors relevant to the development of self-regulation, as well as the role of diverse contexts such as income, safety, environment, and accessibility in shaping parental promotion and control of children's activities, is also vital. More research is needed in diverse low and middle-income countries (LMIC) to further this endeavor and determine how these factors influence socio-cognitive development and child-rearing practices (Cook et al., 2021).

Parenting is not a homogenous practice, even within communities from the same cultural group or country. What is deemed good parenting or a normative behavior for one family, subculture, or culture may not be considered so in another (Bornstein et al., 2012; Cook et al., 2022; Lin et al., 2023). In addition, while cultural norms may influence the parenting style adopted by particular populations, families might not follow them consistently. Other factors, including socioeconomic challenges, such as work demands, location, social class status, or caregiver education, may also impact child rearing practices (Lin et al., 2023; Talib et al., 2011; Trommsdorff, 2012). Parenting practices must be contextualized within local social and cultural norms in high-risk environments. For example, parents who raise their children in unsafe environments tend to exhibit less autonomy and use more control and less scaffolding than those who raise their children in safer environments (Baker & Perry, 2022). More research is needed to fully understand the effects of living in high risk environments on parenting practices and how these can mediate the impact on the development of self-regulation (Cook et al., 2022).

Parents transmit their values, attitudes, and goals to children throughout their development (Spera, 2005), and children learn to conform to their community's group-specific behaviors and attitudes and to transmit these cultural practices (Clegg et al., 2017). Thus, children's ability and willingness to regulate their behaviors are tied to societal expectations and their motivation to behave consistently with these expectations (Jaramillo et al., 2017; Yanaoka et al., 2022; Yanaoka et al., 2024). Similarly, adult attitudes and beliefs towards children's behavior and their role in society reflect culturally-mediated social norms, expectations, and community standards such as conformity, obedience, and discipline (Clegg et al., 2017; Cook et al., 2022; Jaramillo et al., 2017; Tardif et al., 2009). Caregivers' attitudes toward children's conformity to desirable behaviors may influence their expectations for children's self-regulation. For example, in Chinese culture, children are encouraged to be compliant and demonstrate self-control; therefore, caregivers and teachers promote and encourage these behaviors (Chen et al., 2003; Chen & French, 2008). As a result, Chinese children may express higher levels of self-regulation.

Children's self-regulation reflects their life experiences and culturally desirable behaviors, including norms and expectations. For example, research using a delay of gratification task has shown that children are sensitive to in-group norms and are willing to wait for a larger reward when told that their in-group, but not their out-group, is willing to wait (Doebel & Munakata, 2018). There is also notable cultural variation in the contexts in which self-regulation is socialized. For example, Yanaoka and colleagues (2022) compared 4-5-year-old Japanese and US children and found that Japanese children waited three times longer for food than gifts, while American children waited four times longer for gifts than food. This pattern is likely explained by the fact that waiting to eat is emphasized more in Japanese customs while waiting to open gifts is more

prominent in US customs, demonstrating how cultural habits can impact children's expression of self-regulation.

Documenting the effects of cultural norms and contexts on the development of self-regulation is likely more informative than drawing broad generalizations based on constructs like independence and interdependence. For example, rural Cameroonian (Nso) and urban Iranian populations have both been considered interdependent cultures, but when compared to urban German samples of children show, they different patterns of performance on self-regulation tasks; Nso children perform better than German children (Lamm et al., 2018); Iranian children do not (Nemati et al., 2023). These findings are likely not inconsistent. Instead, they reveal the inadequacies of categorizing highly complex cultural communities based on overly general typologies. Increased interaction with multiple and sometimes different cultural practices and beliefs could also impact children's opportunities to practice their regulatory behaviors and learn new skills to help them control their responses.

Variations in gender roles, equity, religious beliefs, values, and identities within and between societies are becoming increasingly apparent due to globalization, migration, and increasing numbers of intercultural families (Barker & Cornwell, 2019). For children from intercultural families, the identity of origin, and the identity developed through formative relationships can influence their behavior (Crippen & Brew, 2007). For instance, parental attitudes and values may differ from the norms of a child's adopted country. Having parents from different cultures can result in different parental expectations that influence the child's behavior (Kim & Hua, 2019). Similarly, immigrant parents may have contrasting cultural models of influence from their birth country compared to the country they have immigrated to.

In addition, children born and raised in an adopted country may identify more with that country's cultural norms than with their parent's birth country. As a result of different combinations of these dynamics above, individuals (including children and caregivers) may adopt various strategies of complete or part assimilation to the adopted culture, blending multiple cultures, and biculturalism, where both cultures are adopted (Bornstein et al., 2012; Crippen & Brew, 2013). These cultural similarities and differences can have complex effects on child-rearing practices and children's customs. Children may encounter conflicting and complementary information and activities that can impact their adaptive decision-making in controlling their behavior - an area of study that requires further research.

Educational Factors

Transitioning from home-based care in infancy to a formal schooling environment is socially and cognitively demanding. Typically, structured school days have defined lesson plans, set break times, and precise start-and-end times. Children are often required to sit at a desk quietly, pay attention to the teacher(s) in the classroom without getting distracted, follow informal rules, recall taught or learned information, and complete required tasks before the end of the school day (Gestsdottir et al., 2014). All aspects of these learning environments place demands on children, requiring them to internally monitor and regulate their behaviors to achieve their educational goals, thereby promoting and indirectly reinforcing cognitive skills such as self-regulation (Gurven et al., 2017; Legare et al., 2018). There are well-documented relationships between young children's academic achievement, including mathematics and literacy, and some self-regulation and EF tasks in the Global North (especially the USA, Europe, and East Asia) and increasingly Global South populations (Cook et al., 2023; Duncan et al., 2018; Gestsdottir et al., 2014; Helm et al., 2019; Ivrendi, 2011; Jordan & Levine, 2009; Kenny et al., 2023; Kim et al., 2020; Lan et al., 2011; Lenes

et al., 2020; McClelland et al., 2007; McClelland et al., 2006; McClelland et al., 2014; Moffitt et al., 2011; Ponitz et al., 2009; Ponitz et al., 2008; Robson et al., 2020; Wanless et al., 2011a; Wanless et al., 2011b; Willoughby et al., 2019; Zelazo et al., 2017). These cross-cultural studies have documented within and between cultural variation in the relations between children's self-regulatory performance and academic performance, providing further support that culture influences how self-regulation and educational success are related (McClelland & Wanless, 2015).

However, the educational input and experiences that underlie the associations between self-regulation and academic achievement require further attention. Information about how educational access impacts the development of self-regulation in populations outside of the Global North is emergent (Piccolo et al., 2021; Piccolo et al., 2022). Although some evidence suggests that higher-quality schools and more experienced teachers impact cognitive development among children in small-scale societies (Gurven et al., 2017), there is a shortage of evidence in populations where schooling is relatively new or sparse. Accordingly, very little is known about how different qualities of schooling, teaching styles, and peer and teacher-student relationship quality shape children's self-regulatory trajectories in populations outside of HIC contexts. In explaining variability in children's self-regulatory and academic performance in diverse, globally representative populations, we advocate for considering other education-based factors, such as school access, school quality, teacher-student relationships, and teaching style. Research on the development self-regulation should go beyond measurement of the ability to comply with testing, game rules, and inhibiting behavior to also examine social influences, responses to unexpected events, and error recovery in children at all levels of educational exposure and attendance (Gurven et al., 2017; Willoughby et al., 2021). Much of what happens in the classroom concerning the

interaction between brain and body systems and education goes unmeasured despite schools' important role in promoting self-regulation.

A fundamental source of educational variation globally is schooling access and quality (Rawlings et al., 2023). Many children worldwide grow up in environments where schooling is unavailable, inaccessible, or irregular. Although there have been advances in access to education, a substantial portion of primary school-aged children do not attend school. According to the UNICEF Annual Report 2022, 64 million school-age children are out of school (UNICEF, 2023). A variety of obstacles can impact individuals' access to and continued attendance at quality schooling: distance to the nearest school, labor requirements in the family unit, children and caregivers' health quality, cultural values and attitudes towards education and schooling, available finances, nutrition, length of the school day, age of entry, school latrine facilities, and to some extents, gender (Adukia, 2017; Beasley et al., 2000; Fentiman et al., 1999; Pasqua, 2005). Obstacles such as these can result in less time in school, ultimately leading to missed opportunities for promoting the development of self-regulation and other cognitive and social developmental skills. Thus, not sampling from populations with varying access to schooling, variation in school quality, and diverse approaches toward teaching and learning limits our understanding of how these factors impact academic success and self-regulation across development. Notably, the impact of formal education is complex; although school attendance increases children's academic performance and cognitive development in children from LMIC (Aboud et al., 2011; Obradović et al., 2016), schooling may not benefit socio-emotional learning and cultural values such as social responsibility (Jukes et al., 2018b).

High-quality student-teacher relationships positively impact young children's sense of belonging, EFs, and self-regulation (Portilla et al., 2014). For example, there is an association

between teachers who provide clarifying instructions and expectations, emotional support, and better classroom organization and better student performance on self-regulation tasks (Sankalaite et al., 2021; Vandenbroucke et al., 2017; Vandenbroucke et al., 2018). In contrast, teacher-student conflict is related to poor school adjustment and academic achievement, impairing children's self-regulation (Li & Lau, 2019; McCormick et al., 2013). However, further research is required to understand how teachers can promote self-regulation by examining the causal effect of different dyadic components from the perspective of the student and the teacher in more diverse communities (Sankalaite et al., 2021).

A supportive social environment provides social buffering under conditions of distress. Parents' and teachers' behaviors can positively (support) or negatively (undermine) children's self-regulation by mediating their child's reactions to others and expressing warmth towards a child. The role of parents as mediators is increasingly important as caregivers worldwide are becoming more involved in their children's education (Sibanda, 2021). For example, when parents in Hong Kong model positive relationships with others and have warm relationships with their children, it can buffer the adverse effects of student-teacher conflict, thus reducing negative impacts on self-regulation (Li & Lau, 2019). Teachers can also serve to buffer children from stress when parenting is high in conflict and low in warmth (Vandenbroucke et al., 2017). Further research on the impact of caregiver-student conflict and the stress-buffering roles of other caregivers in LMIC would be beneficial to examine if these effects extend beyond communities studied in HIC. Moreover, it is crucial to consider student-teacher relationships from a global perspective, where not all children have consistent access to educational resources. In such environments, a high-quality teacher-student relationship may be pivotal in mitigating the negative implications of limited education access and facilitating self-regulatory behaviors.

As children grow and develop within and across home and educational settings, they may face conflicting or complementary educational worldviews, impacting self-regulation (Manning, 2017). Caregivers worldwide can have various attitudes toward schooling and their children's academic performance. For instance, caregivers' teaching style, their attitudes toward teacher-student relationships, their expectations of their child, their involvement in their child's education, and other demographic factors such as SES can affect children's access to, attendance, and attitudes toward learning and education (Clegg et al., 2021; Gonzalez-DeHass et al., 2005; Gužíková & Mendelová, 2022; Li & Lau, 2019; Spera et al., 2009; Wong, 2008). There are complex relations between parenting style and self-regulation and between self-regulation and education; thus, it is important to consider the potential interplay of parenting style and caregivers' attitudes to education to understand how these impact the development of self-regulation. Although there is evidence suggesting that parenting style and involvement can influence children's academic achievement (Cui & Greggor, 2024; Shobola et al., 2012), whether parental attitudes toward schooling and their parenting styles mediate self-regulation is unclear (Duncan et al., 2018; Polat & Bayındır, 2022). Instead, the relationship between parental attitudes towards schooling, parenting style, and children's self-regulation is complex and requires further research among globally-representative populations.

Beyond their role in impacting children's academic performance, caregivers such as teachers and parents influence the social context that shapes the development of children's self-regulation (Žerak et al., 2024). In addition, caregivers' attitudes towards how they think their children should behave at home and how they guide and respond to their behaviors can affect children's behavior in the school environment. Parental involvement plays a critical role in school readiness by fostering key skills (Gonzalez-DeHass et al., 2005; Polat & Bayındır, 2022) and

socializing academic values and practices (Puccioni, 2015; Taylor et al., 2004). Synchrony between child rearing (including parenting style), teaching style, and the educational values of parents and teachers may benefit children's self-regulation (Chao, 1994; Chen et al., 1998; Lan et al., 2011; Zhu & Chang, 2019; Žerak et al., 2024). Caregivers, however, can emphasize academic achievement over other activities, which can also impact children. For example, some parents prioritize academic achievement over other critical needs, such as sleep and play (Yang & Shin, 2008). For other parents, despite demonstrating a positive attitude towards education, barriers such as available resources, knowing what activities to promote, and safety concerns can hinder parents' availability to support these ideals (Dighe & Seiden, 2020). These are important considerations to bear in mind for children worldwide at a potential disadvantage due to a lack of access rather than parental intent. Accordingly, the interaction between a child's home life and educational experience is complex. Further research is needed to understand how different educational factors, such as quality and access, influence the development of self-regulation in diverse cultures. Including broader and cultural considerations when evaluating children's self-regulatory performance beyond typical developmental milestones and the expected benefit of formal schooling on their performance is critical.

Environmental Stressors

Children's environments are multifaceted; surviving under stressful and challenging conditions requires adaptations and trade-offs made possible by flexible cognitive abilities (Boyd et al., 2011; Duncan & Miller, 2002). Thus, a child's goals, demands, and expectations will vary across contexts, resulting in different strategies (von Suchodoletz et al., 2015). As Belsky and colleagues (2012, pp. 662) note, "Because both stressful and supportive rearing environments have always been part of the human experience, developmental systems have been shaped by natural

selection to respond adaptively to both putatively "positive" and "negative" developmental contexts." Variable environments, social expectations, or experiences may promote or hinder various aspects of cognition, including self-regulation. Thus, children's upbringing and all the elements of their environment and culture as well as changes or consistencies interact to shape child development (Belsky et al., 2012).

Insufficient income can result in limited access to cognitively stimulating learning materials, reducing caregivers' opportunities to help promote and support their child's self-regulatory cognitive development (Díaz & McClelland, 2017; Storksen et al., 2015). Children with wealthier parents tend to benefit from increased parental investments in providing more learning resources (e.g., books and toys), access to professional childcare, and more social interactions (Bernier et al., 2010; Bradley & Corwyn, 2002; Duncan & Brooks-Gunn, 1997; Evans & Rosenbaum, 2008; Farah et al., 2006). Collectively, these elements provide an environment that is low in stress and presents opportunities to practice regulatory behaviors conducive to neural and cognitive development (Bernier et al., 2010; Evans & Rosenbaum, 2008).

Growing up under stressful or adverse conditions can negatively impact cognitive performance by directly undermining development, health, and learning or via confounding variables (Munakata et al., 2023; Segretin et al., 2016). Therefore, examining the complex relations between adversity and child outcomes is critical. Children's exposure to unfavorable environments or continual exposure to high-risk environments can cause adverse stress and impact the behavioral and neural indices of the development of self-regulation (Aurino et al., 2020; Evans & Rosenbaum, 2008). Additionally, financial challenges can indirectly affect the development of self-regulation in children through parental stress and conflict, food insecurity, resource availability, and poor mental health of both child and caregivers (Obradović et al., 2010). Continual concerns over lack

of resources can also compromise parents' availability and responsiveness, resulting in changes in parenting style and available resources to promote enrichment opportunities that promote cognitive development (Brody & Flor, 1997; Evans & English, 2002; Mesman et al., 2012). For instance, a meta-analysis of 46 observational studies published between 1974 and 1996 found a moderate association between negative parenting behaviors of children aged between 2 days and 16 years and maternal depression (Lovejoy et al., 2000). Although there was variability in the effect sizes when considering child age, timing of depression, socioeconomic status, and variances in the observations, this research indicates how adverse parental mental health can impact parenting style and subsequent self-regulation (Gündüz et al., 2015).

Whereas low SES can impact the quality of living in some contexts through reduced access to resources, education, and nutrition, potentially impairing self-regulation, high-quality environments in low-SES families can mitigate these effects (Lipina & Evers, 2017; Lipina et al., 2013). Familial relationships and other close relationships can provide social buffering, conferring various benefits to brain development and systems involved in self-regulation (Hostinar & Gunnar, 2015). This highlights the critical interaction between the environment and childrearing practices and the importance of studying globally diverse populations.

Notably, not all studies show SES-related deficits in performance. Research comparing EF performance between South African and Australian children showed that most low-SES South African children outperformed middle- and high-SES Australian preschoolers on several measures of EFs (Howard et al., 2020). Research conducted in South Africa and Gambia (Milosavljevic et al., 2023) examined associations between EF performance and SES indicators, including household assets, caregiver education, family enrichment factors, enrichment activities, and diversity of caregivers. Although children in South Africa scored higher on all EF tasks than

Gambian children, children in both countries scored within the expected range for their age. The associations between EFs and household or familial variables in both countries were weak. These studies challenge the assumption that children in low-income settings have poorer EFs due to lower SES. More research is needed to identify predictors of EF performance in diverse, globally-representative communities to examine these complex relationships (Milosavljevic et al., 2023).

Instability that increases uncertainty about whether children's needs will be met creates a condition in which they must learn more about the world to seek resources or safety, if necessary, in addition to noticing cues that may signal positive or distressing outcomes (Obradović, 2016). Children experiencing the impact of difficult circumstances may make decisions that confer an immediate gain as an adaptive strategy to their circumstances, such as high current needs (Belsky et al., 2012; Delgado et al., 2024; Ellis et al., 2017; Ellis & Del Giudice, 2019; Mittal et al., 2015). Children in challenging situations may show more short-term gratification than the long-term planning and control required for self-regulatory behaviors, showcasing an ability to make ecologically-relevant decisions (like other species: Fawcett et al., 2012).

In addition, children may adapt to their environment and demonstrate unique cognitive strengths and abilities despite their circumstances (Ellis & Del Giudice, 2019; Ellis et al., 2017; Mittal et al., 2015). There is evidence that exposure to stress due to being in adverse conditions during development can improve learning, attention, perception, memory, creativity, and problem-solving in ways that are ecologically relevant to these circumstances – a form of resilience (Dahlman et al., 2013; Ellis et al., 2017; Engel de Abreu et al., 2012; Frankenhuis & de Weerth, 2013; Haslam et al., 2019; Mittal et al., 2015). Despite increasing hardships and risk factors, the cognitive system is flexible and can respond to and learn from disadvantageous conditions to shape cognition (Ellis et al., 2017; Obradović et al., 2023).

There are a variety of ways that different cultures use social support and practices, including music, dance, crafts, art, healing, spirituality, habits, and rituals, as potential resources for supporting resilience in a way that also supports healthy brain and body development (Chen et al., 2023; Legare et al., 2022; Ungar et al., 2023; Wilkie et al., 2022; Yanaoka et al., 2024; Yanaoka et al., 2022). Children living under adverse circumstances require basic needs complemented by culturally-relevant activities that support self-regulatory behaviors and resiliency. Examining self-regulation under conditions of distress will better describe the variance in the adaptive nature of behavior based on a child's environment, experience, and situation demands (Fawcett et al., 2012)

Future Directions

The fact that children learn to control their behavior through cultural learning requires researchers to study global populations (Gündüz et al., 2015). Recent advances in social and cognitive science have made progress in diversifying the populations studied and improving the ecological validity of the methods employed to study the diversity of human behavior (Barrett, 2020; Broesch et al., 2020; Burger et al., 2023; Greenfield et al., 2003; Hamamcı et al., 2021; Keller et al., 2004: Legare, 2017; Muthukrishna et al., 2018; Park et al., 2021; Wei et al., 2023). Despite these strides, more progress is required (Apicella et al., 2020; Draper et al., 2023; Nielsen et al., 2017; Qu et al., 2021). By targeting more diverse populations, future work should document how socioeconomic, cultural, educational, and environmental factors interact to impact the development of self-regulation (Barrett, 2020; Broesch et al., 2020; Greenfield et al., 2003; Haslam et al., 2019; Keller et al., 2004: Legare, 2019).

Studying more diverse communities will present new challenges as researchers need to understand more about each population while also seeking to avoid imposing their cultural values on the groups they study (Gaskins & Alcalá, 2023; Singh, 2024). Doing so will ensure that

experimental designs are suitable and appropriate while also considering the participant's perspective of the experiment (Jukes et al., 2024; Obradović, 2024). By including diverse populations in experimental studies of self-regulation across the age span, researchers can document the sources and potential causes of variation in the development of self-regulation within and between populations. In studying the positive and negative effects of individual experiences, socialization practices, and environmental stressors, researchers will ultimately help explain variation in self-regulation and discover new ways to support children's development (Cook et al., 2024; Gurven, 2018; McClelland & Wanless, 2015; Nielsen et al., 2017; Obradović, 2016).

Conducting more inclusive research will help change unrepresentative and inaccurate views of human cognition and behavior, seek to uncover universal developmental pathways, reduce over (and under) generalizations, and prevent inaccurately (overly) attributing cognitive development to cognitive maturation instead of cultural learning and socialization (Gaskins & Alcalá, 2023; Hruschka et al., 2018a; Hruschka et al., 2018b; Legare et al., 2018). Documenting cultural variation in cognition will challenge and expand views about the cultural universality of cognitive processes and record cultural richness (Rowley & Camacho, 2015). It will also help move the discussion of marginalized children away from deficits and towards cultural strength and responsivity (Draper et al., 2024; Miller-Cotto et al., 2022).

Designing a globally representative developmental science of cognition, including self-regulation, requires considering, documenting, and explaining cultural variation. Researchers must avoid the assumption that a protocol designed for one population will be adequate for all populations while considering construct validity and cultural nuances (Burger et al., 2023; Kline et al., 2018). There is renewed interest in designing new experimental testing paradigms to study self-regulation to include culturally-specific methods and applications of contextual validity, such

as incorporating locally relevant materials and appropriate designs in assessments informed by cultural norms and differences in participants' life experiences (e.g., familiarity with numbers, letters, and two-dimensional shapes and objects (Hruschka et al., 2018b; Lee et al., 2002; Munakata et al., 2020; Zuilkowski et al., 2016). This research first relies on identifying underlying biases and assumptions and then refining common developmental task paradigms developed using Western, highly educated populations with culturally-specific methods and applications (Kline et al., 2018).

The development and deployment of sensitive and accurate measurement of the contextual factors that influence self-regulation is essential (Gurven, 2018). More accurate and convergent assessment using a variety of measures from the child, their caregivers, and educators is necessary (Tamis-LeMonda et al., 2008). Measures should include but not be limited to structured experimental tasks adapted for use in understudied populations (Nielsen et al., 2017). They should also include observational and survey measures created in collaboration with community members and cultural experts to accurately provide in-depth insights into children's developmental trajectories. Researchers should use more sensitive response-capturing methods to document cultural variation. For example, some populations lack experience with Likert scales, skipping questions in varying degrees and adjusting their answer selection depending on whether the questions were positive, negative, or neutral (Lee et al., 2002).

Future research would benefit from ethnographic studies conducted prior to the design of quantitative methods (Amir & McAuliffe, 2020; Zelazo et al., 2024). Focus groups with local community representatives can help inform experimental design and ensure culturally sensitive methods gathering data (Tamis-LeMonda et al., 2008). Culturally-relevant information can help experimental design, administration, and interpretation. What may be commonplace for a

researcher may not be for the study participants or their caregivers. For example, to make their experiment more culturally appropriate for Japanese children, Munakata and colleagues (2020) utilized the sticker real-choice (delayed gratification) paradigm rather than offering children food rewards, as has been the norm with the Marshmallow Test (Mischel, 2014). It is ethical and culturally sensitive to make contextual modifications to existing paradigms, such as understanding food rewards and compensation agreements. Utilizing self-regulatory experimental task designs that do not require a reward framework (such as the Heads Toes Knees and Shoulders (HTKS) Ponitz et al., 2008; Ponitz et al., 2009; McClelland et al., 2014; and the HTKS-R for younger children; McClelland et al., 2021) present new opportunities to develop our understanding of how children's direct and indirect cultural experiences influence the development of self-regulation.

Even when using more culturally sensitive tasks, it is crucial to consider that they involve some aspect of assessment in an experimental setting - this may not be the norm for all populations, especially those outside HIC who may be less familiar with formal testing and assessment contexts. Low literacy levels and inexperience with experimental testing paradigms such as scales can result in misunderstanding and, therefore, performance not being a true reflection of ability along with low concordance between ratings and performance-based measures (Ardila, 2018; Obradović et al., 2016). Thus, efforts should be made with the study population to ensure they are comfortable within these settings and to address any underlying assumptions by the experimenter, participants, or their caregivers (where applicable). It is also critical to ensure that instructions are intelligible to the participants and those administering the tasks (Amir & McAuliffe, 2020). For example, when adapting a computer-based battery of tasks of EFs from the U.S. for tablet use in Kenya, Willoughby and colleagues (2019) discuss the importance of explaining the intent of the task as well as the instructions during translation to ensure the objectives of the tasks are met when

delivering the experimental protocol. Piloting batteries of tasks in this manner can also assist in developing experimental paradigms, helping to improve validity, checking for cultural relevance, and making modifications where necessary. Trialing how long the tasks take for participants of different ages and abilities is especially important when working with children to reduce the risk of participant fatigue. Including non-verbal measures also reduces biases associated with verbal processing demands (Obradović et al., 2024).

Studying cognition and behavior at multiple levels of analysis in diverse populations will also allow researchers to describe and explain variations in regulatory behavior across development and contexts (Amir & McAuliffe, 2020; Pierre et al., 2023; Schmitt et al., 2019; Von Suchodoletz et al., 2015). Self-regulation and related constructs like EFs involve multiple complex cognitive processes; thus, examining children's performance on numerous tasks allows these muti-dimensional skills to be better understood (Duckworth & Kern, 2011; Nketia et al., 2024; Segura et al., 2024). Multiple measures of complex cognitive processes, such as EFs, are highly recommended (Obradović et al., 2024; Obradović & Willoughby, 2019). Tasks that researchers assume measure the same cognitive process may instead be a product of confounding with culturally specific educational experiences (Legare et al., 2018). Different assessments of self-regulation may assess different processes, constructs, and adaptive behaviors of children in various contexts (Von Suchodoletz et al., 2015). By utilizing several culturally sensitive assessment types, researchers can document global diversity in children's self-regulatory development, diversify the selection of tools available for researchers, improve accessibility, and learn more about the adaptive nature of children's self-regulation in different contexts (Legare et al., 2018; Pope et al., 2019).

Conclusion

The development of self-regulation is shaped by the interaction of neurobiological maturation and influences from the sociocultural settings children inhabit (Morrison et al., 2005). Because behavior depends on many factors that interact to shape and form developmental constructs, addressing context-specific variance is essential to understanding how children learn to self-regulate. The enormous variation in children's self-regulation cannot be captured by studying self-regulation in a single population in one context with one task. Instead, exploring the dynamic relationship between familial, educational, cultural, and environmental factors and their interactions in globally representative populations is vital to understanding self-regulation's development and selective expression across ontogeny. There is no single source of variance in the development of self-regulation; a synergy of biological, sociocultural, and environmental factors shapes individual trajectories. Therefore, the criteria for self-regulation may look very different across development, within and between populations and contexts, and as a result of the type of adaptive regulation experienced by individual children. The science of self-regulation should examine the cultural experiences that shape development, and measuring self-regulation in context should be done using empirically-based recommendations. With these insights in mind, the global scientific community will build a more inclusive science of how children learn to control through culture.

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