Self-Regulation in the First 3 Years of Life: A Key to Predict Successful Development?

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Abstract

Self-regulation (SR) skills in young children are known to predict later achievements, but we still know only little about how various aspects of SR first emerge, how they are related to each other and what mechanisms underlie their development in infancy and beyond. To answer these questions we need to improve concepts and measures to describe early SR development, clarify whether SR development undergoes a sensitive period in infancy, and to identify factors that influence SR development in early years. The present report argues for a multi-method, system-oriented, and dynamic approach to meet these challenges.

During early childhood, children learn how to adapt to new situations at the mental and/or behavioral level by modifying their own cognitive, emotional and/or motivational states. In the literature, this capacity is often referred to as self-regulation (SR), serving as an umbrella term for various concepts, such as central attention, emotion regulation, impulse control, executive functions, effortful control, self-control, or metacognitive control (Nigg, 2017). Each concept covers a somewhat different aspect of SR, depending on which target process needs to be regulated (i.e., cognitive, emotional or motivational), whether SR is referring to the mental or to the behavioral level, and whether it is treated more like a state or a trait. Concepts also vary in terms of their interpretation of SR as an innate predisposition or as an acquired skill.

Numerous studies suggest that SR abilities in children predict mental or physical health, academic achievement, and social skills in later years. The Dunedin study provides a well-known example: This longitudinal study started in the early 1970s and followed the lives of more than 1000 people in New Zealand from toddlerhood to adulthood. Moffitt *et al.* (2011) computed

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an integrative rating of self-control (SC) for each child, based on the performance in laboratory tasks and behavioral evaluations by different people (experimenters, caregivers, and teachers) at multiple measurement points (ranging from 3 to 10 years of age). Hence, SC was treated as the behavioral expression of SR skills even though we cannot tell what specific aspects of SR were covered by this compound measure. SC correlated substantially with later drug abuse and addiction, academic performance, income and financial planning, criminal record, and the risk of being a single parent at the age of 32, even after controlling for IQ and SES. When considering only data collected at the earliest measurement time (i.e., when children were 3 years of age) corresponding effects were smaller but still significant. Hence, the Dunedin study demonstrated that SC can already be assessed at a very early age, seems to remain fairly stable throughout development and has important implications for later development.

This raises a number of important questions: For example, we may ask whether using a compound measure provides the best way to capture early SR development, or whether we should assess various aspects of SR skills separately to learn more about their individual role. In any case, it would help to define SR components and their potential precursors more precisely and to use corresponding definitions as a starting point for developing new methods to test infants and toddlers, as reliable and valid measures for this age group are still sparse. This would also enable us to investigate the emerging structure of SR. Furthermore, we could explore whether inter-individual differences in SR are innate, whether infants need a specific input during a sensitive period of brain maturation in order to develop their full potential regarding SR, and/or which experiences in early childhood might have a positive or a negative impact on SR development. Ultimately, work along these lines will help us to determine whether SR can actually serve as a key to predict successful development.

Against this background we thus see two major challenges for future research: (i) improving concepts and measures to describe early SR development; and (ii) clarifying the role of experiences during infancy and identifying potential determinants of SR development. This essay aims at providing the reader with more detailed information on each challenge and with some guidelines for future research.

IMPROVING CONCEPTUAL CLARITY AND MEASURES TO DESCRIBE EARLY SR DEVELOPMENT

Despite the great progress in research on early SR during the past decades (Blair, 2016; Diamond, 2013), we still know only little about how this capacity emerges in first place. In newborns, largely separated lines of work focus

on self-regulation of physiological needs (sleep and food intake), emotional responses (stress), cognitive processes (attention), or motivational (intentional) states. In later infancy and toddlerhood, the role of cognitive and behavioral control becomes increasingly important, as reflected by work on effortful control and executive functions. Even though many authors speculate about potential cross-links between physiological, emotional, cognitive, and motivational SR, longitudinal studies that assess multiple components of SR in parallel and systematically explore their inter-dependence across early years are still rare. As recently pointed out by Nigg (2017), bottom-up and top-down processes of SR should be analyzed in their interplay—a topic that seems of special relevance when talking about the very beginnings of SR and its changes throughout early childhood. Corresponding work would require conceptual clarification, however. It would also require measures suitable for testing the same aspect of SR in an age-adaptive way across early childhood. To illustrate the difficulties associated with a corresponding approach, we take executive functions (EFs) as a prominent example:

Conceptual Clarification and Behavioral Measures—The Example of Executive Functions

EFs are typically interpreted as a top-down mechanism of SR (Nigg, 2017) and defined as a hierarchical construct (Miyake *et al.,* 2000), including the abilities (i) to hold and update information in working memory, (ii) to inhibit dominant, fast, and nonreflected responses to stimulation, and (iii) to flexibly shift the focus of one's mental frame (Blair *et al.,* 2005). Together, these three abilities involve frontal-lobe processes that allow the child to gain and maintain cognitive control in challenging situations. The hierarchical structure of EF proposed by Miyake *et al.* (2000) fits with data for school children and to some extent even preschoolers. For infants and toddlers, results seem rather inconsistent, however (Garon, Bryson, & Smith, 2008). Here, we still know little about how individual EF components are organized, and how they are related to other aspects of SR (e.g., emotion regulation). This raises the question of how EFs can be reliably assessed in very young children.

Even though some computer-based test batteries for EFs in older toddlers, preschool, and school children are available (Zelazo *et al.,* 2013), methods that allow for adaptive testing and age-sensitive measurements applicable under the age of three are largely missing. This makes it difficult to investigate whether EFs should be regarded as stable personality characteristics or as a set of malleable skills.

The availability of such methods would also allow us to investigate the emerging structure of EFs and its changes in early years. The fact that infants have only a limited attention span and limited abilities to understand or

follow verbal instructions implies that paradigms applicable for infants need to be simple and short. At the same time, they should allow researchers to increase task-difficulty for testing older children without changing the concepts. To provide an example of how such an experimental paradigm might look like and what kind of problems researchers encounter when trying to adapt it to different age groups we will describe a set of tasks to assess visuo-spatial working memory as one central and well-defined component of EFs.

Developmental psychologists probing working memory in young children often refer to the general *Hide-and-Seek Paradigm* (Bernier, Carlson, & Whipple, 2010). In this paradigm, an attractive target is placed (or presented) in one of multiple locations. Next, all locations are covered for a predefined time interval before the child is allowed to search for the target. From trial to trial, the hiding location changes; hence, the child needs to update the position of the target to search in the correct location. In task versions for infants, anticipatory looking to the hiding location can serve as the dependent variable (Ropeter & Pauen, 2012). For older infants and toddlers, manual search paradigms are more common (Diamond, 2013). To adjust task difficulty for preschoolers and school children, the hiding locations are sometimes mounted on a round platform, which can be rotated (while being covered) before the child is allowed to start searching. It this case, children typically fail to find the target on the very first trial and need to seek for it repeatedly. That way, the experimenter can check whether the same location is visited more than once, as this measure indicates the child's ability to hold in mind all previously searched locations. This manipulation also implies a change of the feedback-structure. Whereas feedback in previously mentioned versions of the Hide-and-Seek paradigm is irrelevant for the next trial, this is not the case when the child is allowed to search repeatedly.

Although Hide-and-Seek tasks may vary with respect to the dependent measure (anticipatory looking vs manual search), the kind, number, and spatial arrangement of hiding locations, the delay before searching, the number of search attempts allowed, and the feedback structure, the general concept (i.e., updating visuo-spatial memory) remains the same. As demonstrated here, it thus seems possible to develop paradigms that are simple, focused on a specific SR component and that can be adjusted for different age groups of children.

Challenges in Planning and Conducting Behavioral SR Studies with Very Young Children

Nonetheless, we need to remain cautious when interpreting findings of behavioral studies conducted with very young children because even subtle manipulations regarding the experimental procedure may change

the meaning of results. In our view, it is very well possible that the observed instability in EF findings for young children can at least partly be attributed to such minor task variations. Getting back to the example of the Hide-and-Seek paradigm, any change of the hiding location between trials requires the child to inhibit the impulse to search for the target at the same location as before. Since it is well-known that manual versions of this task are generally more demanding than visual versions (Cuevas & Bell, 2010), we cannot rule out the possibility that this change in the dependent measure affects the outcome. Furthermore, the specific mixture of working memory and inhibition skills required may differ between tasks that allow the child to search for the target only once (as this is typically the case in tasks for younger children) in comparison to multiple times (as this is often the case in tasks for older children).

If tasks for older children provide more overlap of distinct EF components, and we study EFs longitudinally, we may thus conclude that all three EF components become integrated with age whereas—in reality—it is the mixture of EFs in our specific tasks that changes rather than the general organization of cognitive processes underlying children's performance.

Furthermore, EFs can be affected by emotional and motivational aspects of SR: Whenever children are offered a reward or are being praised for their performance on a given trial, this is likely to increase their motivation to succeed. Very young children are highly sensitive to social cues and typically show better performance when the experimenter provides them with emotional and motivational support. When working with toddlers, it is almost impossible to not provide social support in order to avoid dropouts. The specific degree of co-regulation may vary between experimenters and the need for co-regulation may vary from child to child. Even though this is likely to have an impact on SR findings, descriptions of experimental procedures in SR research only rarely address this issue. Moreover, systematic research on the impact of task manipulations and experimenter behavior in research with young children is still missing even though a theoretical framework for planning corresponding work (i.e., PROSECO—PROcess of SElf- and CO-regulation in dyadic task settings) is already available (Pauen & the EDOS group, 2016).

To improve behavioral research on SR at a very young age, researchers should standardize the procedure to increase comparability of interactive quality, emotional support, and feedback-structure across different experimenter-child dyads and across different studies. A detailed description of the procedure that highlights aspects relevant for evaluating the degree of co-regulation provided would also be helpful. Yet another way to de-contaminating performance in SR-tasks from the impact of social influences, would be to use eye-tracking paradigms and

computer-programmed feedback systems. These methods are still very rare in SR research with infants and toddlers.

Investigating the Structure of SR in Early Childhood: A Call for Multi-Method Assessments

Conceptual and methodological challenges multiply when the goal is to learn more about the structure of different SR components. This is probably one of the main reasons why coherent models relating different lines of SR research in infancy and toddlerhood are not available.

To illustrate the conceptual difficulties that any model-building implies, EFs can again serve as an illustrative example: Zelazo and Carlson (2012) recently introduced the distinction between "hot" and "cold" EFs, thus highlighting the fact that tasks requiring "cool" problem solving and tasks requiring "hot" regulation of emotional or motivational states activate different brain regions. This leaves us with the question what "hot" EFs are and how they match to or differ from the concept of ER. Cognitive strategies are often needed to effectively deal with emotional arousal or intentional states, and this is what Zelazo and colleagues refer to. But emotional and intentional states may also have an impact on cognitive performance and this impact may even include a time delay, as indicated by recent evidence. Seehagen, Schneider, Rudolph, Ernst, and Zmyi (2015) found that previously stressed infants revealed less flexibility in subsequently administered cognitive tasks. The authors thus speculate that a lack of ER (i.e., stress regulation) in infancy leads to reduced performance in shifting tasks.

To assess different aspects of SR in parallel, it seems helpful to combine behavioral tests in laboratory settings with other data: researchers primarily interested in ER often refer to cortisol-measures (derived saliva, hair, and blood), testing how strong a given child responds to a given stimulation and/or how fast she recovers from externally induced arousal. One can also take heart measures (e.g., heart rate changes or variability) as indicators of emotional arousal and their temporal dynamics. Importantly, physiological and neurophysiological measures may also be useful for probing cognitive SR, even though corresponding studies are still scarce (Feldman, 2015; Schneider-Hassloff *et al.,* 2016).

In addition, caregiver questionnaires can provide complementary information since they cover everyday behavior (Evers, Walk, Quante, & Hille, 2016). Some inventories to asses SR skills have already been introduced to the literature (e.g., BRIEF-P; Gioia, Andrews, & Isquith, 1996), but more instruments are needed that focus on the development of specific SR components in nonclinical populations. It should be noted that such data is always confounded with the quality of the relation between the child and

the caregiver. Hence, it would seem useful to design instruments that allow for an assessment of the interplay between parental expectations regarding their child's SR at a given age, the child's SR competencies (as perceived by parents) as well as parental strategies to deal with situations that require co-regulation. A first attempt in this direction has already been made (IMMA 0–6; Bechtel-Kuehne, Strodthoff, & Pauen, 2016).

Ecological momentary assessments (EMA), a new technique to document the frequency and duration of specific behaviors or states during the day by using a smartphone app provide a promising way to monitor children's behavior and/or caregiver responses in everyday settings. Corresponding data would allow us distinguish between state and trait aspects of SR more precisely.

Finally, we should provide more evidence for the external validity of different SR-measures. New methods need to be validated by correlating them with performance in other tasks probing associated skills. For example, it makes sense to correlate performance in specific EF tasks with performance in tasks assessing problem-solving, planning, perspective taking, theory of mind, creativity, or social understanding. Corresponding studies for older children already exist but more evidence for toddlers is still needed (Pauen & Bechtel-Kuehne, 2016).

In sum, future work can promote the field of research on SR in infancy and early childhood by (i) defining concepts more clearly, (ii) developing paradigms that assess the same specific aspect of SR across different ages, (iii) providing a detailed task-analysis and discussing the potential overlap with other aspects of SR, (iv) standardizing and/or monitoring experimenter behavior carefully, (v) remaining careful when it comes to generalizing findings, (vi) combining physiological, neurophysiological, behavioral, questionnaire and EMA data, (vii) providing evidence for the validity of new SR-measures, and (viii) using a multi-method approach. Only if we improve our conceptual and methodological approaches will we be able to advance knowledge about the development of SR skills, their inter-relation, and structure across the first years of life.

CLARIFYING THE ROLE OF INFANCY AND IDENTIFYING RELEVANT DETERMINANTS FOR LATER SR

Some authors assume that SR skills are part of infants' temperament, whereas others point out that later SR capacities depend upon early experiences. Regarding postnatal development, the great majority of researchers assume that SR skills result from a combination of genetic predispositions, brain maturation, and experiences.

Infancy as a Sensitive Period for SR Development?

So far, we do not know whether SR development is a continuous process. This view is supported by the fact that the frontal lobe is closely associated with EF development and shows rapid and continuous growth of neural connections throughout the early years. Furthermore, top-down control of cognitive, emotional, and motivational states or behavior seems to emerge gradually throughout early childhood. Alternatively, SR development may undergo a "sensitive period" during infancy and early toddlerhood. A sensitive period is a predefined time window of brain maturation during which learning experiences of a specific kind are most critical for later capacities (e.g., SR skills). Considering the fact that SC performance at 3 years of age is predictive for long-term outcomes (Moffitt *et al.*, 2011), this idea seems plausible. In any case, the relevance of the first years for later SR needs to be further clarified.

To learn more about the specific timing of SR development, its biological basis, and the impact of external influences, researchers would have to (i) assess SR skills from birth onwards at different levels, (ii) identify and monitor closely external stimulation and its impact on SR development over time, (iii) find brain correlates that inform us about changes in SR competencies at a young age, (iv) compare the impact of critical experiences during different time intervals (maybe even manipulating them), and (v) check for the long-term outcomes in SR skills. In any case, it seems important to take a dynamic perspective on early SR development.

As will be argued in the following section, there is good reason to assume that social experiences in infancy and toddlerhood are of special relevance for later SR development, thus indirectly supporting the idea that the early years are highly critical for later SR development.

Identifying and Evaluating Social Determinants of SR Development

Caregivers play a central role for shaping infants' brain and SR skills in the postnatal phase (Bernier, Beauchamp, Carlson, & Lalonde, 2015): Stable positive relations, positive parenting, and interactive sensitivity of the caregiver are all associated with secure attachment, better social competencies, and better SR in later years. According to the literature, an authoritarian parental style associated with clear rules, high demands, but also warmth, openness, and responsiveness to the child's needs, has a positive impact on SR development whereas a more harsh and punitive parental style has negative effects (Ispa, Su-Russell, Palermo, & Carlo, 2017). But we shall also keep in mind that the association between social experiences and SR development is bi-directional in the sense that that poor SR skills of the child can lead to increased stress levels in caregivers, which—in turn—reduces

the likelihood to show positive co-regulation. Whether all SR components are equally affected by social influences and which type of social experience is supportive or harmful for SR development under which circumstances, still needs to be investigated.

With regard to the first question, it seems intuitively plausible that inhibition skills or ER vary with caregivers' interactive style. It is the caregiver who needs to co-regulate the child (e.g., by calming him down in states of fear, anger, frustration, or pain, or by reminding him to refrain from actions that might be harmful). How often and in which manner caregivers provide corresponding support is likely to influence children's SR development. In a recent study from our lab, we used the IMMA questionnaire (Bechtel-Kuehne *et al.,* 2016) to explore this issue. In this study, high parental expectations regarding SR of their child were associated with more compliance of the child in situations when parents asked their offspring to show inhibition (i.e., to respect a prohibition). In the same study, negative parenting strategies (e.g., becoming angry or shouting at the child in cases of conflict) were associated with less impulse control in the child. Due to the correlational nature of this study, it is not possible to draw any causal conclusions at this point. Since ethical considerations prevent researchers from systematically manipulating how caregivers treat infants, a different approach would be to study caregiver–child interactions longitudinally and to run path analyses exploring how infant and caregiver-behavior as well as interactive quality jointly affect SR in the child. An interesting avenue for future research might also be to explore how the frequency, temporal delay, degree, and kind of caregiver support in response to the child's calls for co-regulation impact the development of various SR components at different ages. Work in this area might also profit from EMA technology.

When exploring the impact of caregiver behavior on SR development, the impact on cognitive SR (e.g., in terms of attention regulation, shifting, or working memory) should not be forgotten! Training studies with kindergarten and preschool children reveal that EF training can be quite effective (Diamond & Lee, 2011), thus suggesting that caregivers' support in developing EFs may also support toddlers' development in a positive way.

All arguments raised so far are not only relevant for parental behavior but also for profession caregivers' interventions (Berry, Blair, Ursache, Willoughby, & Granger, 2014). Even though positive parenting, high-quality childcare as well as early EF training all show positive effects on SR development, more detailed knowledge is needed about which strategies of caregiving, upbringing, and education work best at what age, for which given caregiver-child dyad, and under which societal conditions. In general, future work should take the broader societal context into account: Factors that directly affect the well-being of adults taking care of young children

(such as workload, financial situation, availability and quality of social support and child care) jointly modulate the stress level of caregivers which in turn affects the SR development of the child via modulating interactive quality. If we want to explain and improve SR in early years, we thus need to take a systemic approach (Bronfenbrenner, 1977) and track the temporal dynamics of interactive quality in the caregiver-child dyad over the first years of life (McClelland *et al.*, 2018).

CONCLUDING REMARKS

SR has been shown to develop early and to be highly relevant for later development. By increasing our knowledge about SR development in the very early period and by linking this knowledge to long-term outcomes, we may improve our means to support young children during a period of development that is most critical for their future well-being, academic, social, and economic performance. This can best be achieved by carefully defining and measuring critical concepts, by exploring empirical relations between them, changes with age, and the interplay of co- and self-regulation in different settings, using a multi-method, dynamic, and systemic approach. Studies considering the issues addressed in this paper will help us shed more light on a promising new key to successful development of the next generation.

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