Universitat Autònoma de Barcelona

DOCTORAL THESIS

Exploring individual differences relations between executive function and parenting styles

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Bellaterra, 2015

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Acknowledgments

Quiero agradecer a mis directores de tesis por la realización de esta tesis doctoral. A la Dra. Ma. Claustre por haber sido un pilar en mi formación, por su comprensión y apoyo. Al Dr. Albert Bonillo por responder en todo momento, por compartirme sus enseñanzas, y ayudarme a mejorar mi trabajo.

Agradezco al Consejo Nacional de Ciencia y Tecnología y al Estado de Querétaro por la ayuda económica recibida para la realización de mis estudios de doctorado en la Universidad Autònoma de Barcelona y la estancia en Virginia Tech.

I would like to thank Kirby Deater-Deckard for let me have the opportunity of being part of his lab; his patience, his leadership, and his sense of humor are qualities that helped me improve myself. También me gustaría agradecerle a Thalía Harmony y a Josefina Ricado, su interés por mi desarrollo profesional y su amistad me ha hecho crecer desde que las conocí.

A mi mamá, porque su amor y su apoyo incondicional ha logrado que yo haya terminado esta etapa. Sus grandes consejos me hacen crecer cada día y avanzar. A mi papá, que por él decidí dejar mi otra vida y continuar con mis estudios. Gracias a él veo la vida con otros ojos. A Claudia Ponce de León, por responder con amor y cariño cuando lo necesitaba. A Emi, porque durante toda nuestra vida no hemos sabido que hacer con este agujerito que se siente cada vez que nos cambian de patio. A Guly por demostrarme que puedo contar con él incondicionalmente.

A Saúl, por que su amor me ha acompañado por este largo viaje. Gracias por tu apoyo, comprensión, paciencia y cariño. Esta tesis no lo hubiera logrado sin ti.

A todos mis amigos que he encontrado en este viaje. A Bruma y Ari por ser las amigas que me acompañaron en este trayecto. Gracias a su extraordinaria amistad los recuerdos han dejado huella. A Vivian y Diego por ofrecerme su amistad incondicional en todo momento; con

risas, pláticas y comidas ustedes han estado a mi lado desde el principio. A Santi, por eseñarme tanto siendo él tan pequeno. A Luz, Lynay, Lucero, Mengjiao, Shereen y Mamatha por ser las personas extraordinarias que conocí en este trayecto. A Aurora, Pilar, Ali y Zeti por ser las amigas de toda la vida. A Paty y a Matias por estar pendientes y compartir todas nuestras experiencias.

Gracias a toda mi familia y conocidos por sus consejos y sus atenciones en todo momento. Este proyecto de vida ha sido increíble porque todos ustedes me han acompañado.

The Study of Early Child Care and Youth Development was conducted by the NICHD Early Child Care Research Network, and was supported by NICHD through a cooperative agreement that calls for scientific collaboration between the grantees and the NICHD staff. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Child Health And Human Development or the National Institutes of Health.

Abstract

In recent years an increasing research have focused on understand how social environment and child executive function interact with each other. Parenting its classified as the most proximal social agent of children, for that reason most of the research have focused on quality parenting on child EF development. However, there still more to understand about it. The follow research evaluates and explores parenting styles and executive functions on two different samples. The first study evaluated mediated effects of both parents EF and child EF via parenting styles (i.e. emotional warmth and rejection). The second, analyzed in a cross-sectional study the associations between both emotional warmth and rejection and child EF. Finally, the third study tested a cross-lagged model to explore bidirectional relations between maternal sensitivity and child EF. The analysis was made with structural equation modeling (SEM). For the first study we used mediated analysis, for the second a direct effect between both variables, and for the third, we tested a cross-lagged model. The results showed a consist effect and relation between negative and positive parenting styles on child EF. The first study showed a partial mediated effect of rejection between mother EF and child EF. The second study presented a stronger association between rejection and child EF, than emotional warmth and child EF. And the third study demonstrated a diminished bidirectional effect between maternal sensitivity and child EF. The results are discussed on terms of the role of EF on the well-being of families, and the trans-generational transmission of EF (i.e. genetic or social training) between parents and children. To conclude, this work state the novelty of the research area, and the importance of treatment to enhance better performance on EF.

Justification

Child development has been a concern for decades. The understanding of how social and cognitive processes evolve through time have gained more and more interest. However, little is known about the area and there is much more to understand about it. One important aspect of these two relations is how the quality of social interactions might or might not influence cognitive processes. A day-by-day routine where child and parents are immersed for years is a good opportunity to study those relations. The quality of parenting practices and their influence on child development is a unique social proximity aspect. Providing information about how the quality of social interaction might influence cognitive process could help to develop strategies and techniques to modify them.

Executive function (EF) is considered a construct that combines several cognitive processes for achieving goal-directed behavior. EF has been an innovating topic which it related to better quality of life, success in school and work, and better social skills. Aside from the biological development associated with EF (i.e prefrontal cortex), in the recent decade, social interactions have taken an important role in this area. Research of quality parenting practices have provided useful information about how daily routines could enhance or affect EF performance. Thus, the novelty of the research limits the current knowledge and urges the need for further inquiry.

The following thesis was made considering the path of individual differences of EF and parenting styles. To investigate these relations, three studies were conducted.

2 Theoretical framework

2.1 Executive Functions

2.1.1 Definition

The concept of executive function (EF) is referring to an umbrella term that encompass several cognitive processes for goal-directed behavior and adaptive responses to different situations (Hughes & Ensor, 2009). EF is not a unitary process, it is a psychological construct with multiple high-level cognitive skills (Anderson, 2008). So, it is considered a variety of cognitive abilities relating different behaviors and emotions that are combined in order to achieve a future goal.

Some of the cognitive abilities that involve EF are: inhibition, attention, planning, shift (i.e. cognitive flexibility), working memory (WM), verbal fluency, among others. There has been a lot of theoretical controversy about which EF component might be more essential than others. In the study of Miyake et al. (2000), they proposed three fundamental components based on the most frequently postulated in the literature: shifting (instead of cognitive flexibility), inhibition and updating of WM. Although they point out that there are more components of EF, several authors have followed this research path. Nonetheless, there has not been a consensus over which EF components are essential to goal-directed behavior.

High and low performance on EF could determine functional adjustment of mental and physical health. According to Diamond and Lee (2011), EF is essential for success in school and life; therefore EF has an impact in cognitive, social and psychological development. Someone with high levels of EF might act differently than another with lower levels. For example, if a person

with high levels of EF gets angry with a friend, he/she might talk things through later on, rather than react in the moment. The person with higher levels might also wait for a healthier snack later on rather than eating an immediate unhealthy treat. The person with lower levels might react impulsively or aggressively to any of the examples just mentioned, and different consequences might await him/her (e.g. losing a friendship or gain rather than loose weight).

A great part of the research of EF has involved poor performance, some authors have considered it a dysexecutive syndrome (Baddeley & Wilson, 1988). According to Anderson (2002) this is not a unitary disorder; it represents a deficit in one or more components of EF. Some of the effects of dysexecutive syndrome are impulsivity, disinhibition, inability to maintain attention, poor self-regulated performance, unable to shift between task demands, and difficulty generating strategies or planning ahead (Anderson, 2008).

These impairments can also be identified in early ages; preschoolers tend to have weaker EF capacities and high emotional reactivity: provocation to anger is very possible (Deater-Deckard, 2014). High deficits in EF has been found on samples with brain injuries (Gioia & Isquith, 2004; Kennedy et al., 2008) and developmental psycho-pathologies, such as attention deficit hyperactivity disorder (ADHD) (Pennington & Ozonoff, 1996), and autistic spectrum disorder (ASD) (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Sergeant, Geurts, & Oosterlaan, 2002).

The study of EF has been growing mostly in the last two decades. According to Scopus databases, there are around 18700 research documents referring to EF at the moment. The biggest impact of EF started in 1980, with child development of EF progressing around the year 2000. The study of EF has evolved in different directions, mostly focusing on frontal brain damage. However, the research process has evolved from EF deficits to promoting individual differences of EF development (Miyake et al., 2000; Miyake & Friedman, 2012).

2.1.2 Frontal Lobes and executive functions

Historically, EF was studied in the context of human brain lesions (Anderson, 2008). Initially, frontal lobe and prefrontal cortex were synonyms of executive function. Luriia (1966) was one of the first to relate prefrontal lobes with high-level cognitive skills, such as programing motor behavior, inhibit immediate responses, integrity of personality and conscience, verbal regulation of behavior, abstraction, and problem solving.

One classic example of frontal lobe pathology and EF disorder is the case of Phineas Gage (Ardila & Ostrosky-Solís, 2008). Phineas Gage was a responsible railroad construction foreman. He survived an accident in which a large iron rod was driven through his head, causing major damage on his frontal lobe. After the accident, he was described as irresponsible and displaying erratic behavior. This case is usually seen as an typical example of EF alterations caused by damage to the frontal lobes.

Over the past two decades, evidence supporting the key role of prefrontal cortex on EF has slightly changed. The recent conclusion is that the relation between the two of them is not as directly dependent as it was believed (Alvarez & Emory, 2006). The advances in technology with neuroimaging and functional imaging have helped to understand other brain regions involving EF (Anderson, 2008). For example, the anatomical substrates with the afferent and efferent structures of the prefrontal cortex (Papazian, Alfonso, & Luzondo, 2006). The dorsolateral prefrontal cortex has been related to mechanical or logical regulation, such as abstract or contextualized problems (i.e. cold EF); while beliefs, desires, self and social understanding, and emotional and personal decision-making (i.e. hot EF) have been mediated by ventromedial or orbitofrontal prefrontal cortex. In other words, there is no isolated act of the prefrontal cortex in EF (D. T. Stuss & Alexander, 2000). Alvarez and Emory (2006) meta-analysis concluded that frontal brain regions are necessary but not essential for EF.

2.1.3 Models of executive function

One of the major problems in this area is the theoretical consensus. Several models have been proposed how EF abilities develop, work together, and evolve. In the following section, six of the most representative models of EF are described: supervisory attentional system, working memory model, model of executive (self-regulatory) functions, problem solving, executive control system and unity/diversity representation. To support every model most of the authors have presented an empirical research evidence, however, theoretical issues are still present.

Supervisory Attentional System (SAS)

It was first introduced by Norman and Shallice (1986). The model considers attention as a central part of a mechanism that operates every action simultaneously. It distinguished between automatic and deliberated resources. According to Norman and Shallice (1986) the term automatic refers to certain tasks executed without awareness of their performance; that includes actions that might be initiated without attention, passively aware of performing an action. In that sense, automatic is performing a task without interfering with others activities. Driving a car, riding a bicycle or turning to hear a noise, are some examples of the automatic mechanism. On the other hand, there are some actions that require deliberate attention; those involving planning, novel sequence of actions, dangerous situations, technical difficulty, or overcoming a strong habitual response. Shallice, Burgess, and Robertson (1996) referred that this model modulates in high and lower levels where prefrontal cortex is the principal modulator for different processes. Later on, D. T. Stuss and Alexander (2000) signaled that the model is the sum of the processes for any task (Figure 2.1). Identifying that most of the processes are highly related to specific frontal regions, between frontal and posterior regions.

The essential components of the model are cognitive units of modules, schemata, contention scheduling, and supervisory (attentional) system. Basic cognitive operations are processes by modules or units, which are controlled by schemata. These

activities can be carried out in routine activities. Hierachies of schemata allow the model to conceptualize more complex routines. Contention scheduling are inhibitory mechanisms that hierarchies between activities. And, finally, the Supervisory system is the general executive component, that works when nonroutine behaviors take place. The Supervisory System can be divided into five components, each one independent from one another: energizing schemata, inhibiting schemata, adjusting contention-scheduling, monitoring the level of activity in schemata, and control of "if-then" logical processes.

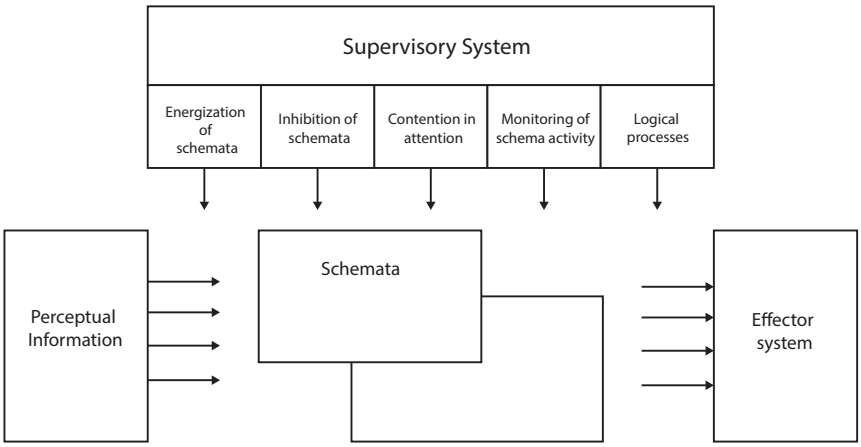

Figure 2.1: Model adapted from "A multidisciplinary approach to anterior attentional functions." by D. Stuss et al. (1995) p. 193.

Working memory model

Baddeley's working memory model was designed to replace the concept of short-term storage. This model refers to working memory as a multicomponent system, information is stored and manipulated,

playing a central role in cognitive processes (i.e. learning, comprehending and reasoning) (Baddeley, 2002). The main concept of the model is based on a system around working memory function. The temporary storage of information is still assumed to be part of working memory, however three more subsystems are introduced: the phonological loop, the visuo-spatial sketch-

apd and the central executive. The first two are storage systems for verbal and visual-spacial information. The central executive integrates the information from the previous subsystems and manipulates the final information. At first the model was presented as the supervisory attentional system, where a central executive regulates incoming and outgoing processes; representing this as homunculus properties in charge of regulating all the processes.

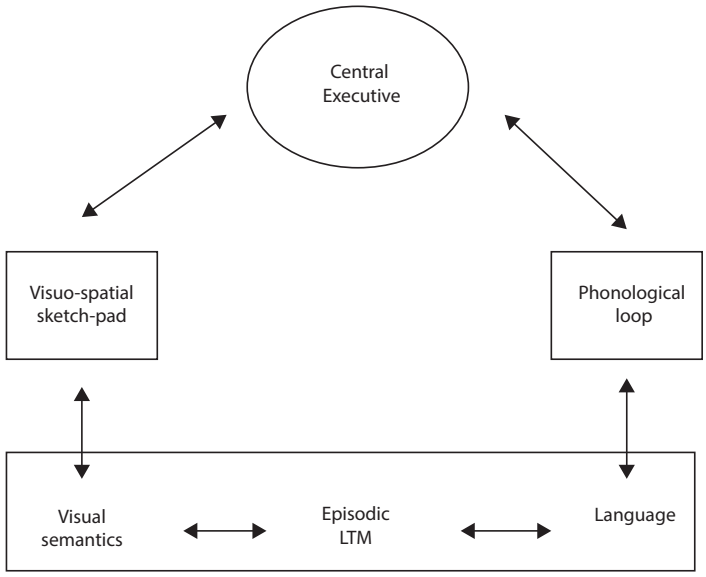

Figure 2.2: Working memory model adapted from "Fractionating the central executive." by Baddeley (2003) p. 196.

Model of executive (self-regulatory) functions

The self-regulation model was introduced by Barkley (1997) with the purpose of explaining cognitive and behavioral deficits associated with attention deficit hyperactivity disorder (ADHD). The theoretical model predicts that the deficiency in behavioral inhibition diminishes self-control and goal-directed behavior. According to the model, inhibition is related with other four executive neuropsychological functions: (1) working memory, (2) self-regulation, (3) internalization of speech, and (4) reconstitution. A deficit in behavioral inhibition in this model is considered to deplete the other four executive abilities, it disrupts the control of goal directed

motor behavior and in turn disrupts the other executive functions (Barkley, 2001).

In Figure 2.3 the model is shown.

There are two important critical issues addressed by Barkley. The extent to which the model specifies deficits in inhibition and its associated executive functions to ADHD or a result of comorbid disorder as aggression, conduct disorder or learning disabilities. Further validation is necessary, as well as targeting remaining unresolved issues, such as whether there is a hierarchical organization of EF, whether they can be reduced, or whether domains are independent or part of a general system.

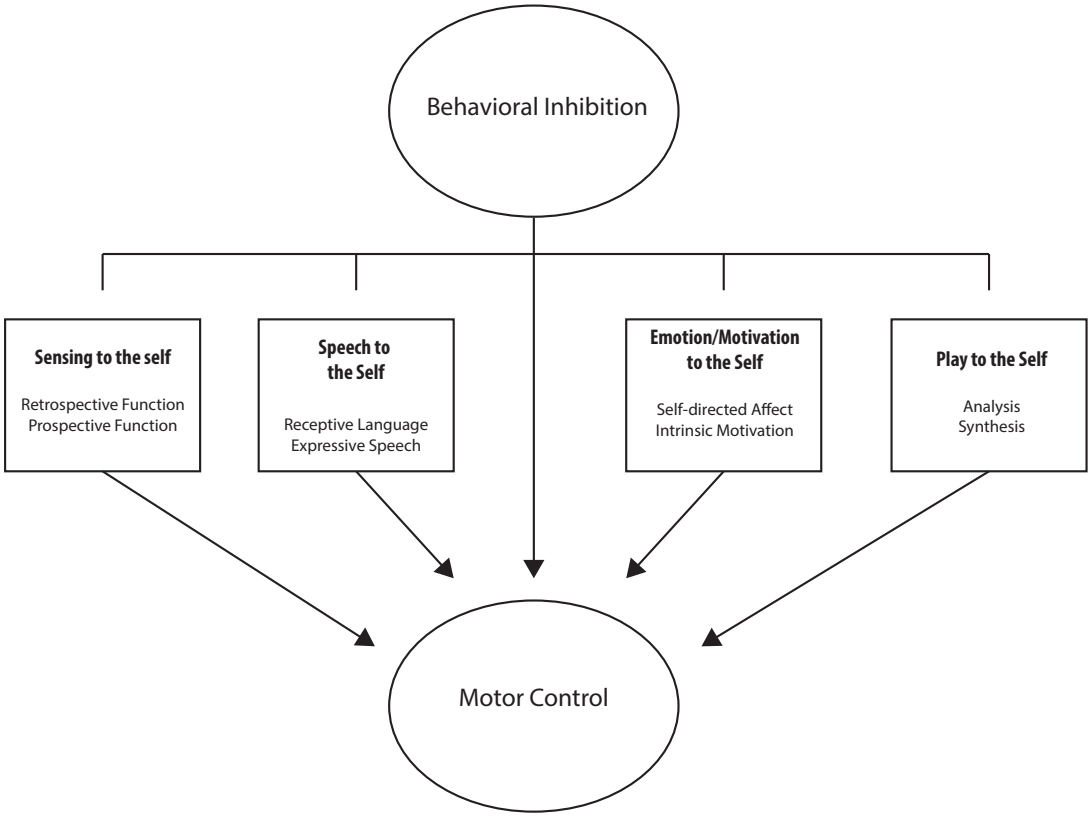

Figure 2.3: Model adapted from "The Executive Functions and Self-Regulation: An Evolutionary Neuropsychological Perspective." by Barkley (2001) p. 7.

Problem Solving Framework

Zelazo, Carter, Reznick, and Frye (1997) presented a model based on a problem-solving framework in which they point out that the ultimate outcome in the case of EF is to deliberate problem-solving. It distinguished four aspects that contribute to the eventual outcome (i.e. problem representation, planning, execution, and evaluation). The model conceptualized well-defined measures for each EF, and hierarchical organization of the EF. It also presented it as a descriptive framework where it does not conceptualize to explain EF, but allows breaking down the process of problem solving performance (Zelazo, Qu, Müller, & Schneider, 2005). Zelazo et al. (2005) considered an evolutionary developmental model, which is highly associated with the prefrontal cortex. Figure 2.4 shows the problem-solving framework. The model represents four important phases: (1) representation, (2) planning, (3) execution, and (4) evaluation, each one considered a step-by-step to achieve an ultimate outcome.

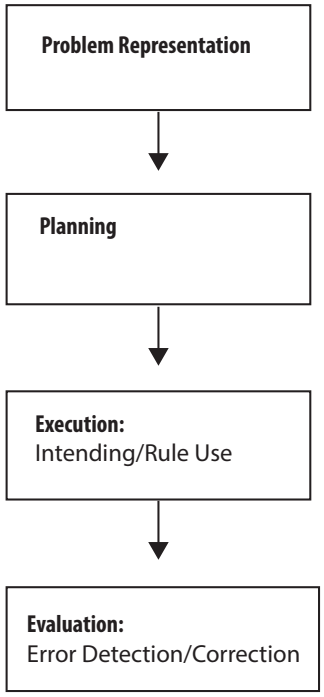

Figure 2.4: Model from "Early Development of Executive Function: A Problem Solving Approach." by Zelazo et al. (1997).

Executive control system

This model was introduced by Anderson (2002, 2008); Anderson and Reidy (2012). It conceptualized EF as a multiple process related system. The conceptual framework came from developmental studies and developmental neuropsychology literature. The model is presented in a functional manner where the domains interact and have bidirectional relationships. It has four main domains: (a) attentional control, (b) information processing, (c) cognitive flexibility, and (d) goal setting. All domains are interrelated and they function as an overall control system. Figure 2.5 shows the model executive control system.

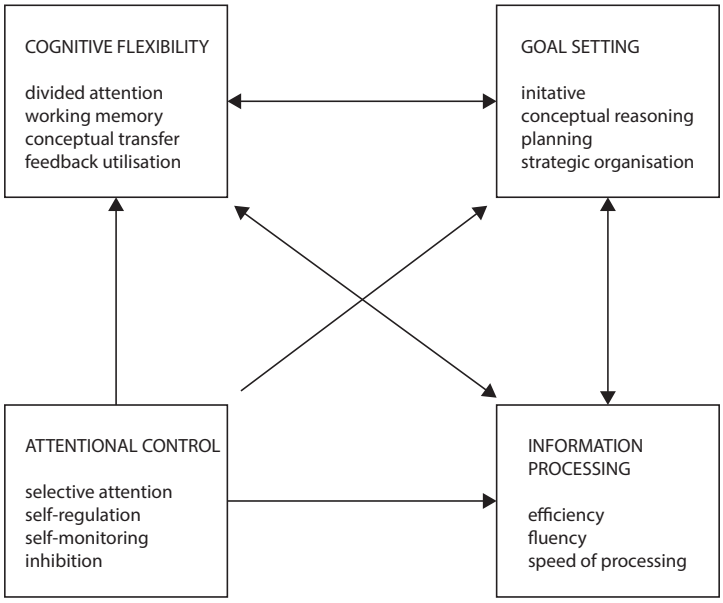

Figure 2.5: Model adapted from "Assessment and development of Executive Function (EF) during childhood." by Anderson (2002) p. 73.

Attentional control refers to the capacity to remain focused for a set period of time, regulate and inhibit actions and behavior, control impulses, and selectively attend to a stimuli. Cognitive flexibility includes abilities such as to cope with changes in routines, switch between response sets, multi-task, process temporarily stored information, ability to transition between and to new activities. Goal setting domain is the ability to initiate, reason, plan, and organize. Finally, information processing refers to the fluency, speed and efficiency when completing novel problem-solving tasks. All domains are highly related to

cognitive processes and each one is conceived to receive and process stimulus from subcortical, motor and posterior brain regions (Anderson, 2008).

Unity/Diversity framework

According to Anderson and Reidy (2012) the EF framework proposed by Miyake et al. (2000) has been highly influential. Miyake et al. (2000) analyzed the three most-used EF in a factor analytic study (i.e. inhibition, working memory and shifting). This model is appealing for the unity and diversity of the EF. Miyake and Friedman (2012) proposed that different EF are correlated to one another (unity), but they also show some separability (diversity).

Figure 2.6 shows the schematic representation of the unity/diversity of the three EF. They also concluded that EF reflect genetic contribution and show developmental stability. Miyake and Friedman (2012) started using neural network modeling in the context of the prefrontal-cortex-basal-ganglia working-memory (PBWM) which provides a biologically plausible model of the brian areas involved in EF. The prefrontal-cortex plays a relevant role in the activation and recurrent connectivity.

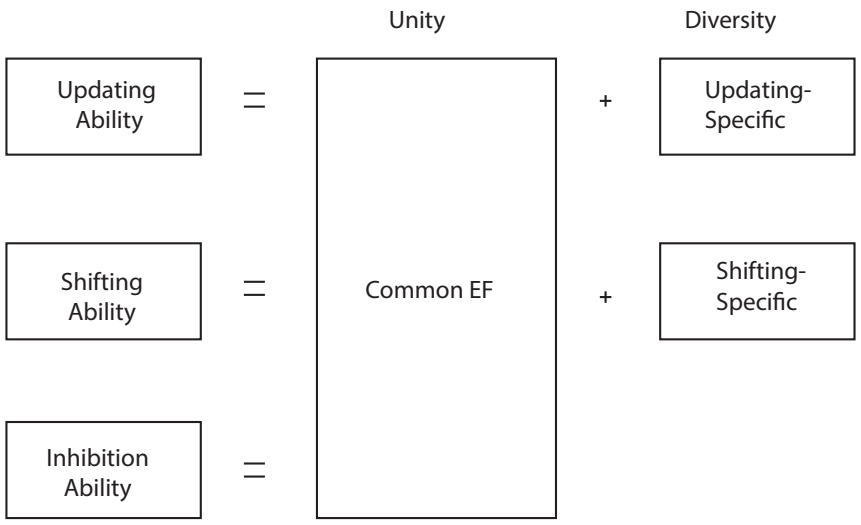

Figure 2.6: Schematic representation of unity and diversity of EFs. Model adapted from "Individual differences in Executive Functions." by Miyake and Friedman (2012) p. 11.

Summary of the EF models

All the models presented above are theoretical efforts to explain several concerns about EF. Most of the authors have developed the model in order to achieve a better understanding of the concept of EF. Some of the basics concerns just presented are how EF components are related to each other, development attributes, and the role of brain regions. A summary of these characteristics are shown in Table 2.1.

The major limitation for each of the models is the reduced acceptance or the lack of general consensus for the explanation of EF. The Supervisory Attentional System and the working memory model have been severely criticized for the homunculus properties. The man inside the machine is a controversial assumption that the models use. Th self-regulation model is validated in clinical sampling (i.e. ADHD). Barkley himself recognized the limitation of the model in community samples.

Zelazo et al. (1997) model (i.e. Problem-solving) is trying to explain EF based on a hierarchy, while Executive Control System associates every dimension in a bidirectional interaction. Those contradictions (i.e. hierarchical organization and bidirectional interaction) to explain how EF components are related to each other shows the poor consensus that exists within the community.

The unity/diversity approach of Miyake and Friedman (2012) tried to standardized the previous problem, recognizing the correlation and self properties of each EF component. However, the model is too recent and it is necessary empirical to validate such organization.

Table 2.1: Summarized of EF models

Model	Homunculus properties	Development attributes	Principal EF component	Specific prefrontal regions
SAS	✓	✗	Attention	✓
Working memory model	✗	✗	Working memory	✓
Self-regulation model	✗	✓	Inhibition	✓
Problem-Solving framework	✗	✓	Problem-solving	✓
Executive control system	✗	✓	—	✓
Unity/Diversity	✗	✓	Inhibition, Working Memory and Shift	✓

2.1.4 Executive function assessment

As we mentioned before, EF is built on several components. According to Best, Miller, and Jones (2009) there are more than 15 cognitive skills involved in EF. Among the most studied are: inhibition, shift (also known as cognitive flexibility), WM, verbal fluency, planning, among others. The assessment of EF has not been an easy challenge. There are many neuropsychological tests for every EF component and there has not been a consensus for measuring it. However, there are some "popular" tasks that have been used repeatedly in some studies (e.g. Tower of Hanoi). Table 2.2 shows a summary of the most studied EF tasks for each component.

In general, there are two ways to evaluate EF: through laboratory tasks and with questionnaires. The challenge for the assessment of EF is to compromise a battery of tasks that are validated for specific demographic characteristic of the sample. For example, several EF tasks have to be adjusted for preschool children. The main reason it that at those ages children are not interested in performing such "boring" tasks; Go/No-Go are adapted into Bear/Dragon and Simon Says (Anderson & Reidy, 2012). However, the challenge continues to contribute to the apparent problem of discriminant validity in a construct as complex as EF (Pennington & Ozonoff, 1996).

Laboratory tasks and questionnaires have contributed, to some extent, to simplifying the measurement of EF. On the one hand, laboratory tasks measure one or two specific EF components; on the other, questionnaires help to evaluate from a more ecological validity. Laboratory tasks measure and validate every EF component and its development or deficit in every assessment. However, there is a large quantity of tasks that have been used for every EF component. For example, inhibition has been evaluated by the stroop task, Go No-Go, Stop-Signal and Matching Familiar Figures Test, among others.

The authors of the questionnaires have been concerned with examining everyday behaviors of EF (Chan, Shum, Toulopoulou, & Chen, 2008; Anderson & Reidy, 2012; Isquith, Gioia, & Espy, 2004; Gioia & Isquith, 2004), given that routines manifestations of EF captures everyday

environment (Isquith, Crawford, Espy, & Gioia, 2005). Rating scales designed to measure executive function in the real world may offer ecological validity to the overall assessment process, including having a better understanding of how laboratory performance test findings may play out in the every day environment (Gioia, Isquith, & Kenealy, 2008). Some of the most common questionnaires are the Cambridge Neuropsychological Test Automated Battery (CANTAB) (Huppert, Brayne, Gill, Paykel, & Beardsall, 1995), and the Behavior Rating Inventory of Executive Function (BRIEF) (Gioia, Isquith, Guy, & Kenworthy, 2000).

2.1.5 EF components and development

EF development has brought to light how every component develops and relates to each other year after year, from early ages to adulthood. As it was discussed in the previous section, there has not been a consensus about how EF components are related to each other. Putting aside theoretical discussion, Garon, Bryson, and Smith (2008) suggested that development EF is partially dissociable which might provide evidence of a hierarchical organization. However, research examining EF in children has been a late-developing phenomena (Brocki & Bohlin, 2004).

Given that there are some consistent findings on child EF development, the following section describes the most popular EF components and the relevant research advances about their development. Table 2.2 presents the most used tasks for every component.

Inhibition

Inhibition refers to a mental process that deliberately holds prepotent, automatic or dominant responses in order to get another result (Miyake et al., 2000; Papazian et al., 2006). The essence of inhibition lies in the suppression of a response or in the control of interfering stimuli competing for a response (Huizinga, Dolan, & van der Molen, 2006).

Diamond (2013) referred that inhibition involves controlling emotions, behavior, and one's

Table 2.2: Executive function tasks and questionnaires

EF component	Task
Attention	Continuous Performance Task
	Digits span forwards and backwards
	Codes test
	Auditory Attention and Response Set (NEPSY)
	Delayed response taks (A-not-B)
Inhibition	Stroop task
	Go No-Go
	Stop-Signal
	Matching Familiar Figures Test (MFFT)
WM	Self Ordered pointing (SOP)
	Woodcok-Johnson
	Continuous Performance Task or N-back task
	Corsi Block (CANTAB)
	Self-Ordered Pointing
	Tic Tac Toe
Shift	Wisconsin Card Sorting (WCST)
	Trail Making Test (TMT)
	Plus minus task
	Contingency naming test
	Necker cube
Planning	Tower of London
	Tower of Hanoi
	Porteus Mazes
Verbal Fluency	Word Fluency Test (TWFT)
	Controlled Oral Word Association Test (COWAT)
Questionnaires	Behavior Rating Inventory of Executive Function (BRIEF)
	Cambridge Neuropsychological Test Automated Battery (CANTAB)

attention over a strong internal predisposition when necessary. A person with low levels of inhibition would react immediately to his impulses, conditioned responses (old habits of thought or action), or stimulus. The most popular tasks to assess inhibition are the Stroop task (Stroop,

1935), and the stop-signal task (Logan, 1994), Go-NoGo (Shue & Douglas, 1992), matching familiar figures test (MFFT) (Kagan, Rosman, Day, Albert, & Phillips, 1964).

Inhibition development is more focal at younger ages. Diamond (2013) explained that there is a major difference in both speed and accuracy of children's performance at ages between 4 and 9 years old. According to Brocki and Bohlin (2004), the most striking development occurred at ages 7.6 to 9.5 and 9.6 to 11.5, with further improvement in older ages. Better performance on inhibition tasks occur during normal aging, however in older adults the performance declines by means of inhibiting visual and auditory distractions (Diamond, 2013).

Working Memory (WM)

In a broad sense, working memory (WM) is defined as an updating function that monitors and manages information over brief periods of time (Best et al., 2009; Papazian et al., 2006). According to Miyake et al. (2000) WM does not store information, it actively manipulates it. WM, in essence, relies on updating information that is no longer relevant and changing it for new and better information (Huizinga et al., 2006). WM has been assessed by several laboratory tasks, however the most common are: Self-Ordered Pointing (SOP) (Petrides & Milner, 1982), Woodcock-Johnson (Woodcock & Johnson, 1989), Corsi Block test (CANTAB(Huppert et al., 1995)), Self-Ordered Pointing (Petrides, 1986), Tic Tac Toe (Milner, 1971).

There has been evidence of a linear increase in performance between 4 and 15 years of age (Best et al., 2009). Although the first glances of WM contents appear between 9 and 12 months. Around the age of 8, with better improvements around 12 years of age, increased WM development appears (Brocki & Bohlin, 2004). Others have not reported such developmental improvements finding no performance difference between 9 and 20 years of age (Best et al., 2009). As the previous EF, WM declines during aging, it appears that WM and inhibition are highly related to each other, as one gets better the other does as well. This is highly reflected in older adults, the more they inhibit distractions, the more WM will be affected (Diamond, 2013).

Shifting

Shifting is also referred to as cognitive flexibility, but Miyake et al. (2000) refers to it as shifting. This is a mental ability to learn from mistakes, divide attention, process multiple sources of information, shift back and forth between multiple tasks, operations, or mental sets (Anderson, 2002; Jurado & Rosselli, 2007; Miyake et al., 2000). It is also considered to be the ability to change perspectives spatially or interpersonally (Diamond, 2013). Some of the most common tasks for evaluating shifting are the Trail Making Test (TMT) (Battery Army Individual Test, 1944; Retan, 1955), and the Wisconsin Card Sorting Test (WSCT) (E. Berg, 1948).

Children between 3- and 4-years-old can reliably shift between two simple response sets (Best et al., 2009). Although children at 2 $\frac{1}{2}$ can succeed in less complex tasks (Diamond, 2013). Further improvements occur between ages 5 and 6 (Best et al., 2009). Task switching improves during child development with a steady increase in all tasks and declines during aging (Best et al., 2009; Diamond, 2013).

The following EF components are not as studied as the previous ones. However, it is worth mentioning them for a better understanding of EF.

Attention

Attention is the ability to focus, maintain, and ignore information that could be considered irrelevant in the environment (Garon et al., 2008). The most common tasks are: Digits span forwards and backwards, adapted from the WISC?III (Wechsler, 1991), codes test (Manly, Robertson, Anderson, & Nimmo-Smith, 1999), Auditory Attention and Response Set (AARS) (Korkman, Kirk, & Kemp, 1998), and Delayed response taks (A-not-B).

The first step to attention development is the orienting system and shift attention, where children go from one stimuli to another. This is initiated during the 1st year of life. After that, between the ages of 2 and 6 years, selective attention starts to develop. At ages 9 and older,

children are able to monitor and regulate their actions accurately (Anderson & Reidy, 2012).

Verbal Fluency

Verbal fluency tasks have been divided into two: phonemic and semantic. Phonemic fluency requires the participants to say or write as many words as possible that begin with a specific letter. Semantic fluency asks the participants to relate with a certain stimulus to each category. Verbal fluency have been assessed mostly by COWAT (Benton & Hamsher, 1989) and the Word Fluency Test (TWFT) (Thurstone, 1938).

As expected, at younger ages children have plenty of difficulties with these kinds of tasks. Better performance on verbal fluency tests develop between 3 and 5 years of age (Anderson, 2002). The older children are, the more likely they are to have a better performance, between 9-19 years and around 11-12 years old significant gains in processing speed are observed (Anderson, 2002). Verbal fluency is the EF component that has the most delayed development (Alvarez & Emory, 2006).

Planning

Planning is the ability to anticipate, identify, organize, and execute complex actions in advance (Anderson, 2002; Jurado & Rosselli, 2007; Verdejo-García & Bechara, 2010). Planning requires a series of difficult cognitive commands in order to achieve the expected result (Verdejo-García & Bechara, 2010). The most common tasks to evaluate planning are: the Tower of London (TOL) (Shallice, 1982), the Tower of Hanoi (TOH) (Simon, 1975), and Porteus Mazes (Mettler, 1949).

The ability to plan up to three moves is present by middle childhood (i.e. using the Tower of London), but a more complex planning is present in late childhood or adolescence (Luciana & Nelson, 1998). Although it has been found that a steady increase in performance evolves from adolescence to adults, it is hard to extract an exact form of developmental trajectory (Best et

al., 2009).

Summary of EF development

In summary, there are different developmental trajectories depending on each EF component. All components show an improvement with age during infancy and childhood, and decrease when aging. Rose, Feldman, and Jankowski (2012) reported there will be infancy implications on substantial long-term aspects even if EF are assessing by 10 years later. The first to emerge by the child's first year is the ability to inhibit some specific behaviors, allowing for increased attentional control. Preschool years are characterized by impressive advances in inhibitory control (Hughes, 2011), although it might reveal maturity between the ages of 6 and 10 (Jurado & Rosselli, 2007). WM also improves rapidly with those ages, indicating a strong relation to inhibition (Brocki & Bohlin, 2004). Planning and shifting seem to develop by age 3 with significant improvement after age 7. Although complex behaviors on tasks focused on these EF are not evident until 11 or 12 years of age (Hughes, 2011). Verbal fluency is last to emerge (Jurado & Rosselli, 2007). All functions improve until adolescence with a sequential progression of the frontal lobe and its connections with other brain areas (Jurado & Rosselli, 2007).

Theoretical statements refer to a test-retest stability on all EF components increasing magnitude reaching adult levels by early adolescence (Deater-Deckard, 2014). Studies of Miyake and Friedman (2012) and N. Friedman, Miyake, Robinson, and Hewitt (2011) have reported empirical research on individual differences of EF stability across points during development.

2.2 Social influences on child development

Children, as part of society, are involved in a great deal of interactions. Parents, extended family, peers, friends, teachers and caretakers are constellations of an integrated system. That involves the children in a cultural and social environment. This system is going to affect behaviors, cognitive processes, and beliefs. According to Baumrind (1980), socialization is an adult-initiated custom that consists of insight, training and imitation of adults to acquire habits and values of the culture.

The environment consists of reciprocal interaction between individuals, which in this case are between family members. The concept of socialization assumes that adults have differentiated but integrated self-systems, capable of defining objectives and then structuring their actions; while children are presented with stimulus to accomplish goals formulated for them by adults.

Rearing behaviors have been considered a crucial factor for children's social, cognitive, and emotional development (Belsky, Steinberg, & Draper, 1991; Bornstein, 2001). The quality of this interaction is related to different emotional and behavioral outcomes on child development (Flouri, 2010) and to cognitive functioning (Belsky, Pasco Fearon, & Bell, 2007; Burchinal, Lowe Vandell, & Belsky, 2014; S. Friedman & Scholnick, 1997; Gauvain, 2001; Jacobsen, Edelstein, & Hofmann, 1994).

Considering that early childhood is a vulnerable life cycle, where humans are especially plastic and children are open to social influences (Maccoby, 2000). Between ages 5 and 7, children's development includes language, food preferences, religious influences and beliefs, and certain enduring personality traits. These developmental paths can be tracked from early childhood up to adolescence or adulthood (Moffitt & Caspi, 2001). In this sense, environmental influences (i.e. parenting, peer relationships) in childhood, for better or for worse, might have life-course effects.

One theoretical approach to explain these complicated social-interactions are through Bel-

sky's theory (Belsky et al., 1991). They proposed an evolutionary theory of socialization, which consists of a casual relation of security attachment, behavior problems, pubertal timing, sexual behavior, parenting behavior and child development. The authors point out that this theory integrates diverse developmental phenomena into an evolutionary perspective, using reproductive strategy as a guiding principle. Some evolved mechanisms are proposed to be defined by conditions of early childhood and have enduring effects on behavior thereafter.

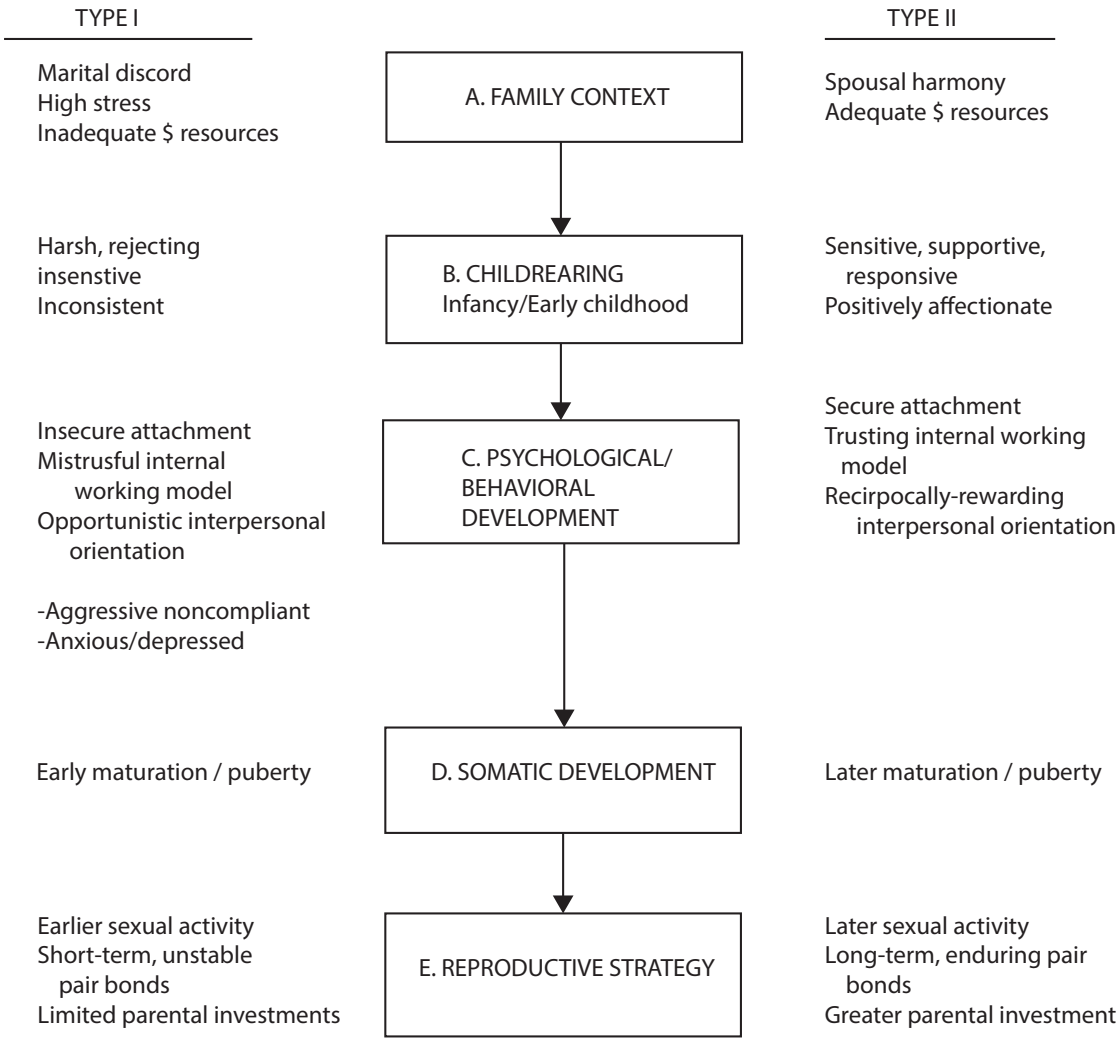

Figure 2.7: Developmental pathways of divergent reproductive strategies presented by J. Belsky

This theory is sensitive to environmental conditions and provides a means to account for individual differences as product of evolutionary theory while maintaining commitment to the psy-

chological unity (Freese, Li, & Wade, 2003). Within this theory, Belsky, Bakermans-Kranenburg, and Van IJzendoorn (2007) theorized that children should vary in their susceptibility to both beneficial and adverse effects of parenting influences. For example, figure 2.7 shows two developmental pathways that involve family context, childrearing, psychological/behavioral developmental, somatic development, and reproductive strategy; both paths explain causality between two different contexts. Hence, how parenting is transmitted across generations and the importance of early experience in the family are an important part of understanding generational transmission (Barrett & Fleming, 2011).

Maccoby (2000) referred that parents have an important impact on their child's development; while Patterson and Fisher (2002) proposed a bidirectional interaction between them. Given this socialization process, a number of research projects have included studies of such interactions.

Evidence related to social influences on child's development have focused on three major areas: (1) familial risk factors, (2) social conditions that affect how well parents interact with their children in a warm and responsive way, and (3) parenting behaviors as mediators of the connection with societal risk factors and children's adjustment (Maccoby, 2000). Parenting has been conceptualized to have an important impact on a child's development; with a directional or bidirectional interaction between parent-child (Patterson & Fisher, 2002). For that reason in the next sections the social interactions are reduced to be only between parenting practices and child development.

2.2.1 Parenting and child development

Within most of a child's everyday environment, parent-child interaction is the most proximal social level, especially within parenting relationships (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012). The quality of this interaction is related to different emotional and behavioral outcomes dependant on child development (Flouri, 2010) and cognitive functioning (Burchinal et al., 2014; S. Friedman & Scholnick, 1997; Gauvain, 2001). Family environments (i.e. household

chaos, SES, maternal education), attachment, scaffolding, and parenting have been social topics related with EF development.

Parenting practices differ on the quality of the interaction. Darling and Steinberg (1993) conceptualized parenting style as a feature of the parent that alters the child's openness to socialization, which could influence towards a more confident or introverted approach. They also referred that parenting style is a constellation of attitudes in which the parent's behaviors are expressed (i.e. gestures, changes in tone of voice, or the spontaneous expression of emotion) towards the child and creates an emotional climate.

The work of Diana Baumrind marked the path of research based on parenting style. Assuming parenting is a socialization process, she suggested that parenting style would affect how open children are to their parents' attempts to socialize them. In Baumrind (1967) she proposed five dimensions: approach-avoidance tendency, subjective mood, parental maturity demands, parental control and parent-child communications. Later on, Baumrind (1996) the dimensions changed to responsiveness, warmth, reciprocity, clear communication and person-centered discourse, and attachment.

That was one of the most influential works by Baumrind; for that reason we are going to define those dimensions according to her work. Responsiveness refers to parents intention to foster individuality and self-assertion by being supportive, attuned, and acquiescent to children's needs. Warmth refers to a parent's emotional love, which motivates children to participate in cooperative strategies. Reciprocity encompasses synchrony between parent-infant interaction. Clear communication and person-centered discourse involves authority of the parent to assigned roles, legitimized parental authority by persuasion. And finally, attachment refers to having a reciprocally affectionate relationship with caregivers.

Others have proposed several others parenting styles. For example, Fay-Stammbach, Hawes, and Meredith (2014) referred that there are four theoretic dimensions: (1) scaffolding, (2) stimulation, (3) sensitivity/responsiveness versus hostility/rejection, and (4) control. Parental scaf-

folding involves deliberate efforts of parents to help children engage with challenging activities. Stimulation involves providing children with opportunities to develop cognitive skills through enriched interactions (e.g. reading). Sensitive/responsive caregiving promotes internalization of regulatory strategies; it is also defined as the ability to respond accordingly to children's signs (Wolff & Ijzendoorn, 1997). Hostility/conflict or rejection are defined by negative affective behaviors with a critical, negative or rejective tone. Finally, control is involved in behavioral control or discipline and can be undermined by negative control.

The extended range of parenting dimensions practices can be divided into two broad aspects: negative and positive (Hughes, 2011). Positive parenting is characterized by sensitivity, warmth, parent involvement, scalffolding, and autonomy support (Waller et al., 2014). Empirical evidence has reported that maternal sensitivity, autonomy support, responsiveness, and parental care predicts child EF (Bernier, Carlson, & Whipple, 2010; Blair, Raver, & Berry, 2014); inductive discipline and maternal warmth was associated to effortful control (Choe, Olson, & Sameroff, 2013) and lower levels of externalizing behaviors (Eisenberg et al., 2005); scalffolding predicts moral reason (Hinnant, Nelson, O'Brien, Keane, & Calkins, 2013). Also, warmth predicts lower levels of callous-unemotional behavior (Waller et al., 2014). In a broad sense, positive parenting promotes adaptive child functioning (Bradley & Corwyn, 2013).

In contrast, negative parenting include harsh punishment, abusive discipline, rejection, intrusiveness, inconsistency, and ridiculing the child (Tung & Lee, 2014). Research findings report that harshness predicts externalizing behaviors (Bradley & Corwyn, 2007); decreased involvement predicts oppositional defiant symptoms (Burke, Pardini, & Loeber, 2008), while poor supervision (Burke et al., 2008) and inconsistent parenting predicted conduct disorder (Gardner, 1989); also, negative control was negatively associated with self-regulated behaviors (Karreman, van Tuijl, Van Aken, & Dekovic, 2006). Figure 2.8 summarizes the effects of both positive and negative parenting on child development.

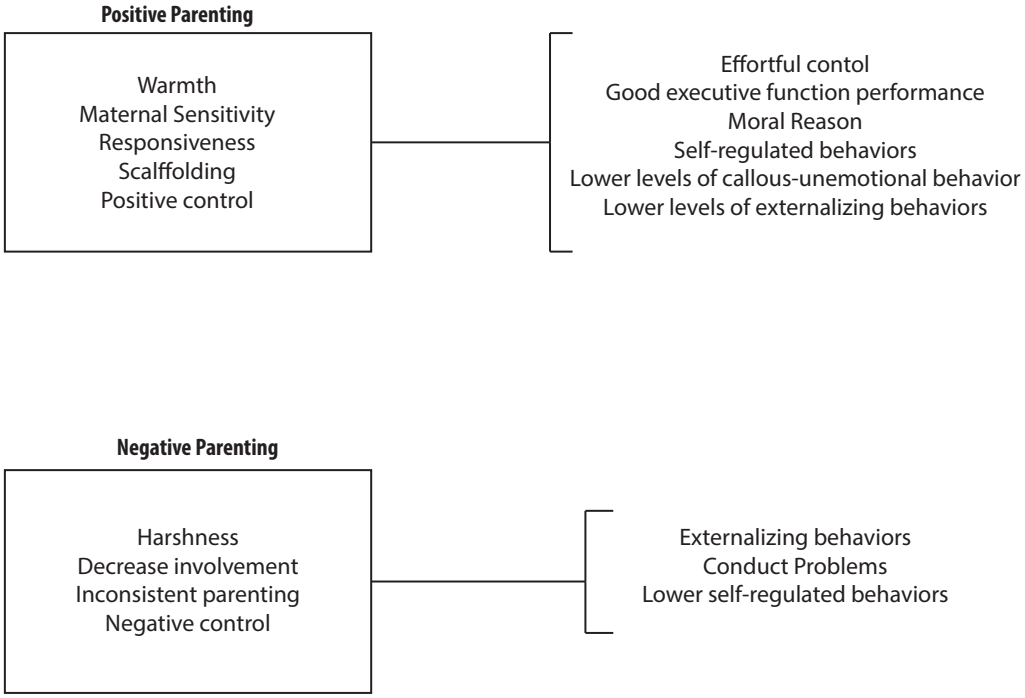

Figure 2.8: Effects of positive and negative parenting

2.2.1.1 Effects of parenting styles on child EF development

During recent years social and attachment theories studied the effects of social interactions on child EF in more specific terms (Bernier et al., 2012; Rhoades, Greenberg, Lanza, & Blair, 2011). According to Hughes and Ensor (2009), there is a slight association between EF intervention research and the effects of social interactions on EF. EF biological development can be determined by specific social environments. Hence, Diamond and Lee (2011) points out that children are continuously trained to do certain activities (i.e. martial arts and mindfulness practices, computerized training, aerobic exercise, and classroom curricula) and these skilled activities might be able to improve their EF skills.

Literature on specific training of EF has tested and supported this claim with preschool children (Dowsett & Livesey, 2000) and adolescents (Beck, Hanson, Puffenberger, Benninger, & Benninger, 2010; Crone, 2009; Zelazo, Carlson, & Kesek, 2008). In this sense, close social relationship interactions and intervention experiments have provided enough evidence to claim that EF might be affected by continuous social exposure in everyday life. Family routine offers daily opportunities for the child to improve and challenge their own EF (S. Friedman & Scholnick, 1997). In specific terms, there is evidence supporting that parent-child interaction is associated with EF but this claim needs further research (Zelazo et al., 2003).

As it was mentioned in previous sections, parenting practices could affect child development in different ways. Parenting quality appears to have different outcomes on child EF. However, researchers have just started to recognize the social and contextual factors that are associated to EF. Most of the research on EF has focused specifically on positive rather than negative rearing practices.

Until now, research on negative parenting styles associated to child EF is very limited. Hughes and Ensor (2006) evaluated tests of theory of mind, EF, and verbal ability in 127 two-year-olds children from disadvantaged families to understand the origins of behavior problems. They also evaluated behavioral problems and harsh parenting and the numbers indicated moderated

correlations between harsh parenting and EF. The power to predict one with other was not studied with the hierarchical analyses.

Furthermore, most of the research related to EF has studied early adversity and has found a relationship between EF and abuse or neglect (Barrett & Fleming, 2011). Talwar, Carlson, and Lee (2011) evaluated punitive vs. non-punitive school environments on West Africa kindergarten children's EF. They found no difference between both environments, with the exception of one grade, where in the punitive school the children performance significantly worse than the non-punitive school.

Research on positive parenting is more extensive than negative parenting, yet the field is relatively new with just ten years of research. Some studies have focused on parental behavior attachment (Bernier et al., 2012), scaffolding (Hughes & Ensor, 2009), and family environment (Rhoades et al., 2011). The most consistent evidence for this subject is on the effects of maternal sensitivity (Blair et al., 2014; Bernier et al., 2010; Kok et al., 2014; Von der Lippe, Eilertsen, Hartmann, & Killèn, 2010; NICHD Early Child Care Research Network, 2005). All evidence has demonstrated a relative effect of positive parenting on EF of children ages between six months and four years of age.

Evidence in developmental EF supported the claim to investigate the relation between parenting and child EF on ages between middle childhood and adolescence; important EF developmental stages occurred during those stages. Brocki and Bohlin (2004) suggests that children in middle childhood show the most striking disinhibition development, between 7.6 to 9.5 years of age and between 9.5 and 11.5 years of age. Also, according to Miyake and Friedman (2012) there is an improvement of EF at 14 years old.

Few studies have specifically centered on parenting and EF in later ages; Schroeder and Kelley (2010) studied the associations between parenting practices in family environments and EF of children between 5 and 12 years old. They used the Behavior Rating Inventory of Executive Function (BRIEF) to measure child EF. The results showed the relation between parental

support and appropriate limit setting with higher levels of EF. Also, Roskam, Stievenart, Meunier, and Noël (2014), in a longitudinal study with children between two to eight years of age, evaluated the relation between parenting and child inhibition. They found that parenting contributed to good development of a child's inhibition. Furthermore, Samuelson, Krueger, and Wilson (2012) studied parenting and child EF development on children in middle childhood and adolescence. In a cross-sectional study with children between 7 and 16 years of age, they evaluated the relationships between maternal emotion regulation, parenting, and child EF in families exposed to intimate partner violence. They found that positive parenting behaviors were correlated with planning and problem solving performance.

This new research field has provided evidence about how positive parenting style could influence child EF in early ages; however, limited research has evaluated negative parenting practices and child EF. Both rearing styles appeared to be related with child EF in early and older ages. However, studies that have analyzed the relation between a positive parenting style and child EF present three main limitations: (1) The lack of replicate reports about the findings with a different type of positive parenting besides maternal sensitivity, (2) no longitudinal studies on later ages, and (3) no comparison within the same sample of both parenting styles.

The narrow picture of the effects of parenting on child EF at different developmental periods (i.e. early childhood, middle childhood and adolescence) encourage exploring the magnitude of positive parenting style through EF child development. It is also important to compare both types of parenting styles in order to evaluate the relations between the two of them. To summarize, current research provides limited resources to understand the relation between parenting styles and child EF. Thys, it would be interesting to observe how those interactions (i.e. between parents and children) are compared or evolve.

2.2.2 Determinants of parenting

How a parent reacts and interacts with their child involves a constellation of behaviors, beliefs, cognitive aspects, cultural and social factors. Parenting takes place in a similar way. According to Deater-Deckard (2014) physiological, cognitive, emotional and behavioral responses are responsible for parents' self-regulation, which has been considered an important factor on parenting behaviors. The next section takes into account how parenting behaviors are involved in EF performance. It is important to signalize that most of the research on this topic have been made with mothers and not with fathers. For that reason most of the following descriptions and research evidence referred directly to the mother.

It is not difficult to consider the fact that EF might be essential to parenting. Evidence has suggested that parents' cognitions are key factors for parenting behaviors (Chase-Lansdale, Wakschlag, & Brooks-Gunn, 1995; Olson, Bates, Sandy, & Lanthier, 2000; Wilson, Gardner, Burton, & Leung, 2006). In most recent years, Barrett and Fleming (2011) mentioned that for the mother (i.e. they specifically determined the term "mother", not parenting), it is necessary to have a system that regulates sensations, affection, reward, perception, motor output, learning and EF. They also proposed that cognitive flexibility, working memory and attentional control are fundamental executive processes to positive parenting (i.e. maternal sensitivity). These processes appear to be highly associated with the dorsolateral prefrontal cortex, one of the brain regions involved in task- or set-shifting.

Crandall, Deater-Deckard, and Riley (2015) presented a review of the increasing interest in parental executive functioning, including emotions and cognitive control capacities. Within this review, Crandall et al. (2015) points out that maternal emotion and cognitive control capacity is related to positive and negative parenting. A good performance on parenting behaviors might include rewards according to the child's behavior, while a bad performance might imply inconsistent reward. Good parent EF might inhibit emotional and angry behaviors towards the child, while a low parent EF might react impulsive and aggressive towards the child.

To have a better understanding of how EF is involved with rearing behaviors, two models of trans-generational transmission have been proposed. Both models explain how EF is part of an integrated system. Deater-Deckard (2014) based his model in self-regulation, while Gonzalez (2015) worked on the transmission of EF between parents and children.

Gonzalez's model (Gonzalez, 2015) (Figure 2.9) based the link between maternal history of childhood maltreatment to higher order cognitive functions. In turn, these cognitive processes may be associated with different child outcomes, or may act via an indirect pathway through maternal caregiving behaviors.

The model is constructed as a way to begin understanding that adaptive parenting requires a wide range of capacities (i.e. attentional control, emotion regulation, empathy, theory of mind, and EF) and that these capacities might affect a wide range of development outcomes for children. Gonzalez suggested that those constructs subsumed by the prefrontal cortex such as EF, empathy, and theory of mind are key elements of parental function.

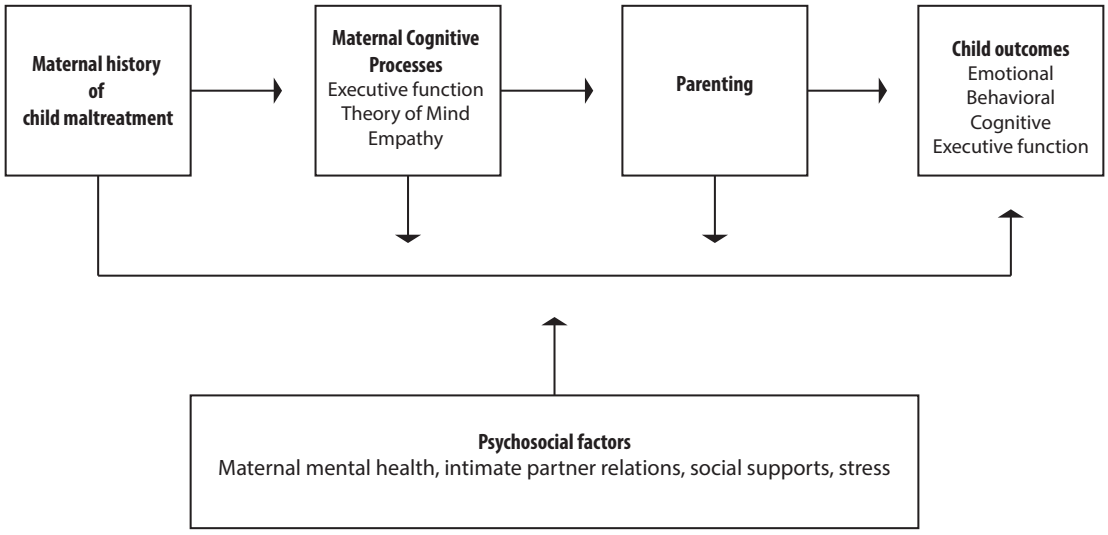

Figure 2.9: Model from "The role of maternal executive function." by Gonzalez (2015) p. 48

Deater-Deckard (2014) presented an heuristic model of familial intergenerational transmission of EF and interpersonal processes in its development (Figure 2.10. The model represents the

parental transmission of self-regulation to their children directly though the socialization processes and biological mechanisms. It also considered the contextual features as socieconomic risks, household chaos, and cultural factors that represent home context.

Individual differences in these features can be assessed from early ages and become moderately to substantially stable by the end of middle childhood, while self-regulatory capacity also improves. At the same time, parents' own EF and cognitive behaviors are affected by their children's behaviors, while children are affected by their parent's caregiving behavior. Futhermore, emotions and cognitive control capacities have a direct impact on parenting, which in turn impacts each developmental stage of child health and development. The quality of parenting may be modified by emotions and cognitive control capacities (Crandall et al., 2015).

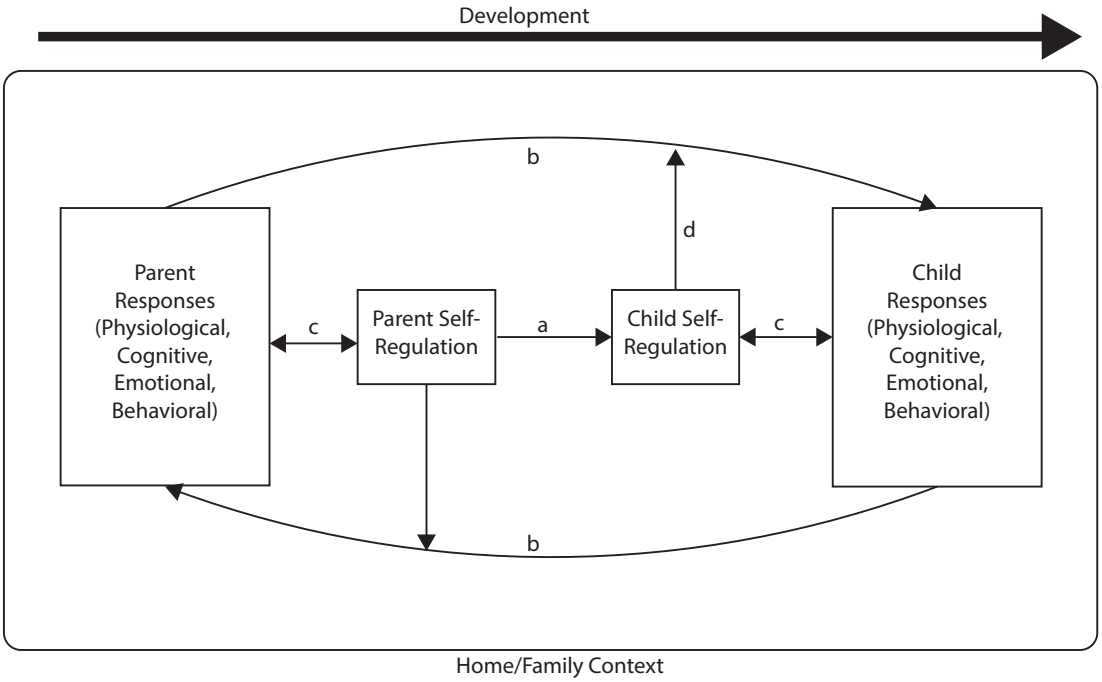

Figure 2.10: Heuristic model from "Family Matters: Intergenerational and Interpersonal Processes of Executive Function and Attentive Behavior." by Deater-Deckard (2014) p.231. Note: (a) In addition, parent's and children's verbal and nonverbal emotional and behavioral responses evoke responses in each other; (b) These responses are directly related to (c) and moderated by (d) self-regulation of thoughts, emotions, and behaviors

These two attempts to explain how parenting practices take place have something in common:

the executive function. It is not that difficult to link high EF and positive parenting; or between low EF performance and negative parenting. Parents require their working memory to be updated, maintained and manipulated information to be planned and guide his/her interaction with her child. Attentional control is needed to focus on his/her infant needs, reacted to accordingly and time appropriately. The parent must inhibit impulsive behaviors and control his/her negative emotions to avoid react in a harsh manner towards his/her child. Shifting is needed to switch their attention across many situational demands and also to respond in a sensitive way to the child's needs. A mother's planning is also determinant to every-day routine, to avoid household chaos and to maintain rules, communication, and cooperative strategies. All those process are fundamental components of mothering -or parenting- and key aspects of a positive or negative parenting (Barrett & Fleming, 2011).

2.2.2.1 Evidence involving parents EF on their parenting styles

Some of the empirical research pursuing the hypothesis that EF is involved in parenting styles has made for an interesting pursuit. For example, the work of Gonzalez, Jenkins, Steiner, and Fleming (2012) and Chico, Gonzalez, Ali, Steiner, and Fleming (2014) worked on maternal sensitivity, while the research group of Kirby Deater-Deckard focused on negative parenting. Firstly, Deater-Deckard, Sewell, Petrill, and Thompson (2009) proposed the hypothesis that maternal working memory could moderate the association between challenging behavior and maternal negativity. Using a quasi-experimental sibling design involving same-sex twins (average age of 6.12 years old), they found that there was a substantially differential maternal negativity but only among mother with poorer working memory skills, as they hypothesized.

Furthermore, Deater-Deckard, Wang, Chen, and Bell (2012) studied maternal EF and household regulation as critical aspects of childrearing. They hypothesized that the link between child conduct problems and harsh parenting would be stronger for mothers with poorer EF and weakest with better EF; also, this mechanism would be moderated by the degree of household chaos. They included 147 mothers of 3-to-7 year old children. As expected, harsh parenting was linked to child conduct problems only in mothers with poor EF; the effect was stronger in calm predictable environments, but not so evident in chaotic environments.

Finally, Cuevas et al. (2014) examine the contributions of maternal EF and caregiving to child EF throughout early childhood. This was a longitudinal study where children were tested at 24, 36, and 48 months of age. They studied negative caregiving behaviors such as intrusiveness, negative affect, lack of psychical stimulation, and failure to facilitate attention. As expected, they also hypothesized that maternal negative caregiving behaviors would negatively correlate with maternal EF as well as with child EF. The results showed that mediation models revealed that the links between maternal EF and child EF at some early ages is only partially explained through maternal caregiving. They also concluded that it is possible that maternal EF are critical to regulate maternal caregiving behaviors, especially negative parenting behaviors.

Positive parenting has been also been studied. Gonzalez et al. (2012) proposed a model examining the impact of maternal early experiences on maternal sensitivity through hypothalamic-pituitary-adernal (HPA) function and EF in 89 mothers and their infants of 2-to-6-years of age. They tested four mediational path analyses in which they found that parental stress (HPA function) and EF are mediators linking early experiences to parenting. Furthermore, Chico et al. (2014) compared teenage mothers against adults, to test if poor EF development, as it is at such young ages, could be associated with EF and mothering. All mothers were approximately at 4-6 months postpartum. As expected, teenagers performed worse than adults on tasks of cognitive flexibility and were less sensitive in their infant interactions. However, the association between EF and mothering occurred in both teen and adult mothers.

Across studies, higher maternal emotion and cognitive control was associated with less child maltreatment and harsh, reactive parenting; lower maternal emotion and cognitive control was associated with higher risk for child maltreatment and more harsh, reactive parenting. On the other side, higher maternal emotion and cognitive control was associated with more positive parenting and time spent con caregiving activities; lower maternal emotion and cognitive control was associated with fewer positive parenting behaviors.

The evidence just presented gives a broad idea of what is known until now about this area of interest. It appears that EF plays an important role on both positive and negative parenting. The effects of EF on negative parenting has been studied on mothers with children between 2 and 7 years of age in different areas: children conduct problems, household chaos and child EF. The findings are consistent with low EF associated with negative parenting, and better EF associated with lower negative parenting.

The positive effects of better EF promoting maternal sensitivity are consistent with previous evidence. A mediated effect of EF and HPA between early experiences and maternal sensitivity has been found, as well as a less sensitive interaction of teenage mothers. Because of this evidence, it is presumed that this effect could be present in later ages, where children are

more independent from their parents and an impact of child development could determine their wellbeing. The absence of the father in every study has reduced the parenting practices to the mother, despite the father being an important figure of the interaction parent-child in many cases.

2.3 Thesis statement

Executive function (EF) is considered an umbrella construct that encompasses several cognitive components. EF development research has investigated how EF components evolve through time. Prefrontal cortex and other brain regions have been associated with EF skills performance and also tanning programs have proved improvement in each EF component. On one hand, brain development could organically improve EF performance through time, on the other, the training programs proclaim the possibility that EF could evolve for better or for worse depending on task adjustment. Hence, given the last possibility, theoretical approaches have provided that social interactions could influence EF at different life-time points.

In modern society parenting practices are considered to be the most proximal social relation between a parent and child. The quality of rearing behaviors has been associated to and predicted both positive and negative effects on cognitive, emotional, and behavioral aspects of children.

According to this, in the last ten years some research has taken place relating EF and social interactions. Most of the literature has focused on investigating the relation between parenting styles and child EF; while newer research has started to understand the role of parents' EF (i.e. especially mothers) on parenting practices. The function of EF between the interaction of parents and children worth should be investigated, given that daily routines could enhance or affect EF development. Also, a deficit of parents in EF could affect their routines and therefore their children.

The research in this area is not as broad as we would expect it to be. The newest research is starting to understand how EF plays a role in harsh parenting practices. One interesting finding of Cuevas et al. (2014) is a partially mediated effect of harsh parenting style between the relation of mother EF and child EF. This indicated that the possible effect of disorganization of EF could affect the trans-generational transmission between mother and child. More research is needed to understand if those relations take place in positive parenting practices or analyzing

the tole of a different caregiver, such as the father, given that most of the research has focused on the mother.

Research on the effects of parenting style on child EF has been more studied. In the last ten years most of the studies have focused on the effects of positive parenting practices (i.e. specifically on maternal sensitivity) on child EF, mostly on early ages. Those who have studied preschool years, middle childhood or even adolescence have provided cross-sectional research. Furthermore, there is limited research on negative parenting practices (i.e. reject, harsh parenting, hostility) and child EF.

To have a better understanding of those interactions we propose three studies targeting further exploration of the relations between the quality of parenting and EF. The following sections present the research project followed by the theoretical framework.

3 Research project

3.1 Introduction

How executive function (EF) develop through the years have been a research interest for several decades. However, in recent years the possibility that the environment plays an important in its development has been widely accepted. The following section presents the research project of three studies focused on understanding how social interactions (i.e. parenting) and EF are involved. The first study analyzes the mediated effects between parents EF and child EF via two parenting styles (i.e. reject and emotional warmth); the second explores the association between both positive and negative parenting practices and child EF; and, the third, evaluates the longitudinal effects between positive parenting style and child EF.

To get this work done, we analyzed two samples: (1) Bages's sample, and the (2) NICHD Study of Early Child Care and Youth Development database. The first sample was collected in Catalunya, Spain, while the second one is from a database from the U.S. (NICHD Study of Early Child Care and Youth Development (SECCYD), for a more detailed description see NICHD Early Child Care Research Network, and `http://www.icpsr.umich.edu/icpsrweb/ICPSR/series/233`).

3.2 Studies

3.2.1 General objective

The general objective of this research project is to evaluate the different relations between parenting styles and EF.

3.2.2 Objectives and hypothesis

Study 1.

Study one is focused on parents' practices determinants. Deater-Deckard (2014) and Gonzalez (2015) point out that EF play an important role on the quality of parenting. We decided to follow the path of Cuevas et al. (2014), where they examined the association between mother EF and child EF mediated by harsh parenting. They suggested that EF is critical to regulating negative maternal caregiving behaviors. To discard the functional role of EF on negative paternal practices, it might be necessary to compare positive and negative parenting practices. Also, the role of the mother has been considered as the primary caretaker, and somehow the role of the father has been put aside. This gives a consideration to analyze and compare the mediated effects of negative parenting practices of both parents.

Objective: Analyze mediated relations between both parents' EF (i.e. mother and father) and child EF via a parenting style (i.e. emotional warmth and rejection).

Hyphotesis: Both EF of mother and father are mediated by rejection.

Study 2.

The second study addresses the association between parenting styles and child EF. According with Fay-Stammbach et al. (2014), the effects of harsh parenting on child EF has not been fully investigated; even when previous empirical research of punitive environments have reported a relation on child EF (Talwar et al., 2011). Until now only one study has researched the

association between negative parenting and child EF (Hughes & Ensor, 2006), and the relations between both variables were strongly correlated. However, they did not perform further analysis on this issue. Considering the slight possibility that parenting might not have an effect on child EF, research on positive parenting practices has reported that there is, especially in young ages (Blair et al., 2014; Bernier et al., 2010; Kok et al., 2014; Von der Lippe et al., 2010; NICHD Early Child Care Research Network, 2005). Findings of cross-sectional studies have supported similar results in ages between 5 and 12-to-16 years old (Samuelson et al., 2012; Schroeder & Kelley, 2010). Assuming that both negative and positive practicing practices are opposite behaviors, it is assumed that negative parenting might have a diminished effect on child EF and positive parenting could improve it. To explore and compare the associations between both positive and negative parenting styles it might be beneficial to compare both positive and negative parenting practices.

Objetive: Analyze the relation between positive and negative parenting style on child EF.

Hypothesis: Positive parenting style is associated with child EF.

Hypothesis: Negative parenting style is negatively associated with child EF.

Study 3.

The third study is related to positive parenting style and child EF. As we mentioned before, the effects of positive parenting style on child EF has been reported previously (Blair et al., 2014; Bernier et al., 2010; Kok et al., 2014; Von der Lippe et al., 2010; NICHD Early Child Care Research Network, 2005). Overall, those studies focused on early ages and left aside middle childhood and adolescence. Even when two cross-sectional studies reported association between positive parenting and child EF (Schroeder & Kelley, 2010; Samuelson et al., 2012), longitudinal research on older ages appears to be the next step, especially to evaluate in middle childhood and adolescent stages. Zelazo and Carlson (2012) address that during adolescence a considerable reorganization of prefrontal systems takes place, which allows oneself to be much more sensitive

to external environment. For this reason, it is pertinent to analyze longitudinal effects of positive parenting style and child EF on children of older ages, to explore how that interaction takes place.

Objective: Evaluate longitudinal effects of positive parenting style on child EF.

Hypothesis: There is an effect of positive parenting and child EF from preschool years to adolescence.

3.3 Method

3.3.1 Bages' sample

3.3.1.1 Participants

A total of 781 families with children between 3 and 12 years old were selected to participate in this cross-sectional study. The sample was collected from 4 locations of Bages, Catalunya. Of the original sample 511 families were willing to participate; 199 were from preschool and 312 were from elementary school. Average children ages were 6.89 (SD=2.65), mother's ages were 37.04 (SD = 5.27), and father's were 40.17 (SD=5.81). As for the parent's education, 41.4% of fathers and 32.2% mothers studied until elementary school, 35.8% of fathers and 34.1% mothers had a high school degree, 11.1% fathers and 17.4% mothers had some college education, and 11.7% of fathers and 16.4% of mothers had graduate studies or a professional degree.

3.3.1.2 Design and procedure

One-wave cross-sectional design was chosen for this study. First, to carry out this study *Serveis Territorials d'Ensenyament de la Catalunya Central (Govern de la Generalitat de Catalunya)* granted permission. Then, the research group contacted the schools and invited the parents of all the schoolchildren to take part in the study. Those who agreed were given questionnaires and release of informed consent forms by the research group. The parents completed the questionnaires at home and then returned them, along with the signed informed consent forms, through the teachers.

3.3.1.3 Instruments

Sociodemographic data

Sociodemographic data recollection was conducted with the Hollingshead (1975) question-

naire.

Parenting Styles

The EMBU-P (Perris, Jacobsson, Linndström, Knorring, & Perris, 1980) Spanish version for adults (Arrindell et al., 1988) was used to measure parenting styles. Scores were obtained on a four-point Likert scale (1 = never, 2 = sometimes, 3 = often, and 4 = always). The questionnaire consisted of 52 items in four dimensions: emotional warmth, rejection, attempts at control, and favoring subject; we used the first two dimensions. In the analysis, emotional warmth was used as a positive parenting style, while rejection was used as a negative one. The emotional warmth dimension measured parental acceptance and physical/verbal/emotional affection through 17 items. Some items were: "You have shown that you are happy with your child" and "You helped your child when he/she had a difficult task in front of him/her." The rejection dimension evaluates parental physical punishment, hostility, disrespect, and inconsistent discipline. This dimension consisted of 13 items; for example: "You have treated your child in such a way that he/she felt ashamed", "You have beaten your child". and "You have been too strict with your child" (Arrindell et al., 1988). Rejection was used as a comparative measure for the analysis.

Executive Function

Behavior Rating Inventory of Executive Function (BRIEF) is a validated questionnaire that evaluates everyday context of the EF components. The BRIEF has demonstrated to have an ecological validity of measuring EF in clinical samples, brain injuries and normal samples (Isquith et al., 2004). The questionnaire was answered by parents of preschool children (BRIEF-P), children at middle childhood (BRIEF), and by both mother and father (BRIEF-A). Scores were obtained with a 3-point scale (1 = Never; 2 = Sometimes; 3 = Often). Higher scores indicate more dysfunctions.

Behavior Rating Inventory of Executive Function for preschoolers (BRIEF-P) (Catalan version by Bonillo, Araujo Jiménez, Jane Ballabriga, Capdevila, & Riera, 2012). The BRIEF-P is a

questionnaire for parents of preschool children with ages between 3 and 6 years of age. Each questionnaire has 63 items divided up into five clinical scales: inhibition, shift, emotional control, WM, and planning/organization.

Behavior Rating Inventory of Executive Function (BRIEF) (Gioia et al. (2000) translated and adapted to Spanish sample by Capdevila-Brophy, Artigas-Pallarés, and Obiols-Llandrich (2006)). The BRIEF evaluates executive functions with a questionnaire for parents of children and adolescents aged 5 to 18. Each questionnaire contains 86 items divided into eight clinical scales: inhibition, shift, emotional control, WM, planning/organization, material organization, monitoring and initiative. This instrument has been demonstrated to have high test-retest reliability ($rs = 0.82$) and internal consistency (alphas -.80, -.98).

Behavior Inventory of Executive Function-Adult Version (BRIEF-A) (Spanish version by Roth, Isquith, & Gioia, 2005). The BRIEF-A is a standardized test that evaluates the EF of adults in their daily lives through the use of self-report questionnaires. It is composed of 75 items with nine clinical scales: inhibition, monitoring, planning/organization, shift, initiative, task monitoring, emotional control, working memory and organization of material. Scores and scales were obtained in the same way as the BRIEF. The means of all scales were used in the analysis. Both mother and father were asked to answer this report.

3.3.2 NICHD Study of Early Child Care and Youth Development sample

3.3.2.1 Participants

The participants of this study were part of the NICHD Study of Early Child Care and Youth Development (SECCYD). In 1991, a total of 1,364 families with healthy newborns were recruited at 10 U.S. locations. In a 24-hour interval, 8,986 women giving birth were selected, the final sample included 1,364 families that completed a home interview and were willing to participate in the study (for a more detailed description see NICHD Early Child Care Research Network, and `http://www.icpsr.umich.edu/icpsrweb/ICPSR/series/233`). Of the original sample of 1,364 participants, a total of 1,009 children were retained at age 15. The average annual income for the families at 54 months old was $54,879.26 (SD = $48,575.37; range: $ 1,000.00 to $54,879.26.00). Most of the sample included European American (80%), while 13% were African American, 5% were multi-racial, and 2% were another race/ethnicity. When children were 1 month old, 31% of the mothers had a high school degree or less, 34% had some college education, 21% had bachelor's degrees, and 14% had graduate or professional degrees.

3.3.2.2 Design and procedure

A three-wave longitudinal correlational study was designed involving repeated measurement of maternal sensitivity and child EF. In each of the three waves, children performed tasks in the laboratory, mother-child interactions were videotaped in the lab (at 4.5 years of age) and at home (at 9 and 15 years of age), and multiple informants (i.e., caregivers, mothers and fathers) completed questionnaires. Assessments occurred at 4.5 years (i.e., preschool/prekindergarten in the US education system), 9 years (i.e., third grade), and 15 years of age (i.e., ninth grade).

3.3.2.3 Instruments

Maternal Sensitivity

Mother and child were videotaped interacting in a semi-structured session at every assessment point; tasks varied by wave/child age. At 4.5 years of age, mother and child interacted in three different tasks; the first two tasks were too difficult for the child, so it required the mother's help and instruction. The first task involved the mother-child dyad completing a maze using an Etch-A-Sketch. The second activity was to build a series of towers with wooden blocks of the same size. In the third activity, they played with six hand puppets. At 9 years of age, the first task involved the mother and child planning an activity, and the second task mother and child had a discussion about some specific topic where disagreement between the two emerged. At 4.5 and 9 years of age, the semi-structured session lasted between 15 and 20 minutes. At 15 years of age, a single task was used. The adolescent chose from a list of possible topics that were areas of disagreement with her or his mother (e.g. chores, homework, use of free time). The mother-adolescent dyad then discussed this topic for 5 to 8 minutes.

Two trained observers measured global dimensions of parenting. A maternal sensitivity composite scored at each time point was formed as the mean of multiple indicators after reverse scoring negatively valence items. Maternal sensitivity composite has been used previously and been associated with child social and cognitive outcomes (Bernier et al., 2010; S. L. Friedman et al., 2014; NICHD Early Child Care Research Network, 2005). At 4.5 years and 9 years of age, three global dimensions were used for the maternal sensitivity composite: mother's supportive presence, respect for the child's autonomy, and expressing hostility (reversed coded) rated by 7-point scales. Cronbach's alpha for the composites were .84 (4.5 years) and .78 (9 years). At 15 years of age, six dimensions with 7-point scales were used: validation and agreement, respect for autonomy, engagement, warmth, reflected inhibit relatedness (reversed coded), and expressing hostility (reversed coded); alpha was .81. Intraclass correlations were used to calculate inter-observer reliability. Average coefficients across raters for 4.5 years, 9 years, and 15 years were .88, .84, and .86, respectively. Since the 15-years composite used more items than the earlier time points, the composites were standardized within each wave, resulting in z-scores with higher scores corresponding with greater maternal sensitivity.

Executive Function

EF was measured as a composite score that included indicators of inhibitory control, working memory, and attention (see Holmes, Kim-Spoon, & Deater-Deckard, 2015). At 4.5 years, the composite was comprised of (1) the average of the mother and caregiver's report ($r = .33, p < .001$) on the attention focusing subscale of the Children's Behavior Questionnaire (Rothbart, Ahadi, & Hershey, 1994), (2) the average of the mother and caregiver's report ($r = .37, p < .001$) on the inhibitory control subscale of the Children's Behavior Questionnaire (Rothbart et al., 1994), (3) the average of the mother and father's report ($r = .41, p < .001$) on the attention problems subscale of the Child Behavior Checklist (Achenbach, 1991), (4) the number of correct responses on the Continuous Performance Task (CPT) (Barkley, 1994) which measures sustained attention, and (5) the standard score on the Woodcock-Johnson memory for sentences (Woodcock & Johnson, 1989) which measures the ability to remember simple words and repeat them back to the experimenter. A principal component analysis (PCA) showed that 45% of the variance was explained by the first component, with loadings ranging from .45 to .82.

At 9 years of age, EF was comprised of (1) the average of the mother and father's report ($r = .58, p < .001$) on the attention problems subscale of the Child Behavior Checklist (Achenbach, 1991), (2) the standard score on the Woodcock-Johnson memory for sentences (Woodcock & Johnson, 1989), and (3) the total planning efficiency score across tasks on the Tower of Hanoi (Anzai & Simon, 1979), which measures the child's planning and problem-solving skills by an organized series of moves to complete a goal. A PCA found that 49% of the variance was explained by the first component, with loadings from .68 to .72.

At 15 years of age, EF included (1) the average of the mother and father's report ($r = .61, p < .001$) on the attention problems scale of the Child Behavior Checklist (Achenbach, 1991), (2) the total score on the Operation Span Task (Turner & Engle, 1989) which measures an individual's working memory, and (3) the number of total moves on the Tower of London task (W. K. Berg & Byrd, 2002), similar to the Tower of Hanoi task used at 9 years of age. A PCA found that

40% of the variance was explained by the first component, with loadings ranging from.43 to .76.

3.3.3 Analysis

To conduct the analyses we proposed three different structural equation models for each study. Descriptive statistics and correlations were estimated using SPSS. The models were tested using Mplus version 7.2 (Muthén & Muthén, 1998-2010). For the first study we proposed a mediated analyses, for the second a direct association, and for the third a crosslagged model.

The following fit indices were used for each model: Standardized root mean square residual (SRMR), comparative fit index (CFI), Tucker-Lewis index (TLI), RMSEA, and χ^2 statistics. On the Bages' sample the use of χ^2 was ruled out because of its sensitivity to number of individuals (Iacobucci, 2010). Instead, χ^2/df was used for its acceptance as an adjustment index in place of χ^2 (Hooper, Coughlan, & Mullen, 2008), for the NICHD sample χ^2 was still considered. A model was considered to have a good fit when the coefficients met the following criteria: $\chi^2 = ns$; SRMR $\leq$ .08; TLI and CFI at or above 0.90 (excellent if above .95) (Hox & Bechger, 1998); RMSEA equal to or less than .06 (Hu & Bentler, 1999).

3.3.3.1 Study 1

The mediator analysis accounts for the relation between the predictor and the criterion. According to Baron and Kenny (1986) mediators explain how external events take on internal psychological significance. The model assumes a system of three-variables: 1) a direct impact of the independent variable; 2) the impact of the mediator; and 3) path from the independent variable to the mediator. As shown in Figure 3.1, the direct impact is between parent EF and child EF (1), the impact of the mediator is between parenting style and child EF (2), the path from the independent variable to the mediator is between parent EF and parenting style (3).

We chose to do this analysis because of the study of Cuevas et al. (2014). They examined with regression analysis whether maternal caregiving mediated the association between maternal and child EF. In this case we decided to test with a structural equation modeling because of number of participants of the sample, and to elaborate a latent variable for every scale of the BRIEF.

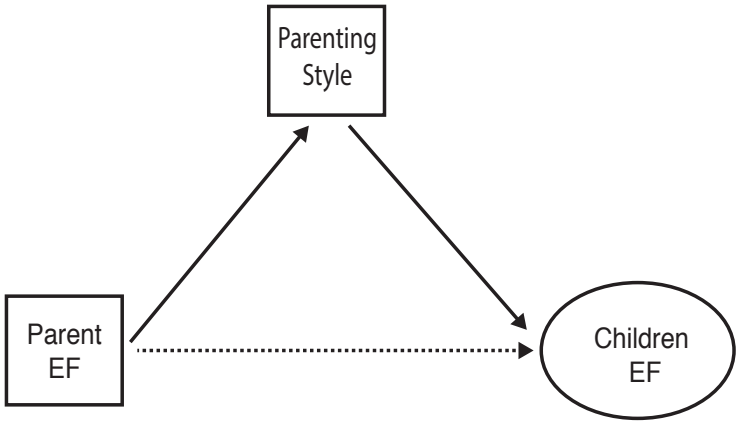

Figure 3.1: Example of a mediation path

3.3.3.2 Study 2

For study 2, we examined the direct relation of both warmth and rejection on child EF in both children groups (i.e. preschool and middle childhood). We analyzed two structural equation models in order to elaborate a latent variable of all EF components. Figure 3.2 shows an example of the tested model.

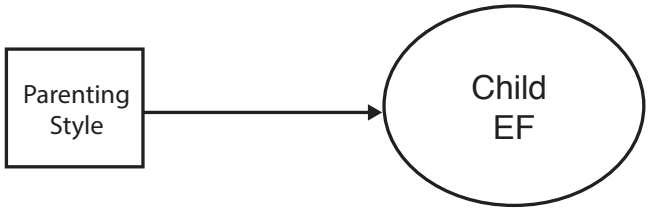

Figure 3.2: Example of a direct model

3.3.3.3 Study 3

A continuous time cross-lagged design was used to examine a two-variable path model that included three stability paths, one for each assessment point for maternal sensitivity and EF. In Figure 3.3 the tested model is shown.

Each path model included concurrent correlations between maternal sensitivity and EF within

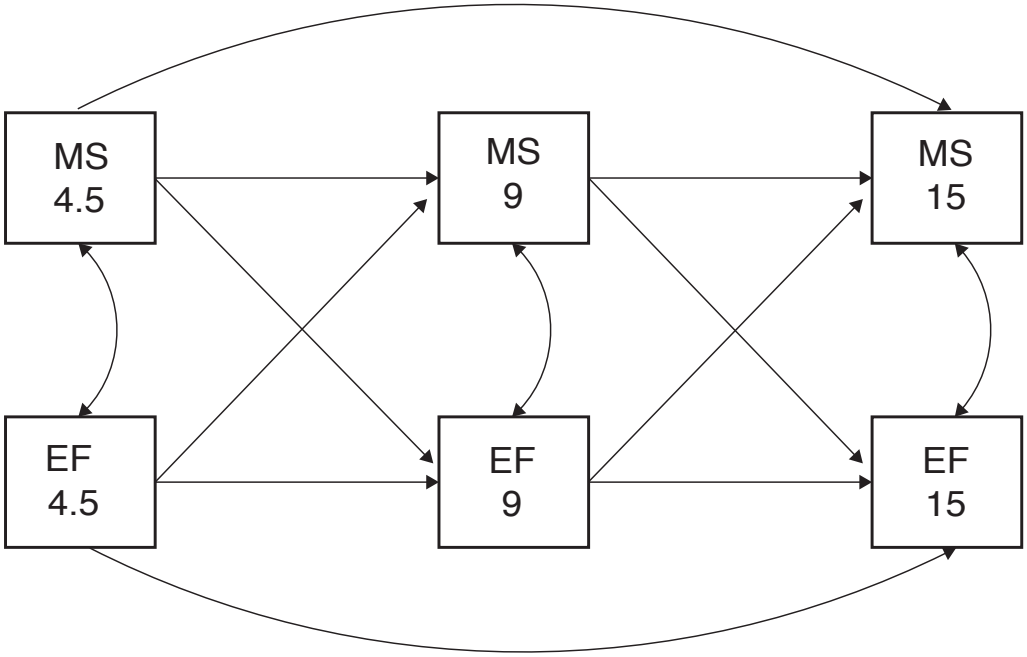

Figure 3.3: Cross-lagged path model of maternal sensitivity and executive function.
Note: MS 4.5 = maternal sensibility at 4.5 years; MS 9 = maternal sensitivity at nine years of age; MS 15 = maternal sensibility at 15 years of age; EF 4.5 = executive function at 4.5 years; EF 9 = executive function at nine years of age; EF 15 = executive function at 15 years of age.

each wave, four longitudinal stability paths (e.g. EF at 4.5 years → 9 years; maternal sensitivity at 4.5 years → 9 years; etc.) and four cross-lagged paths (e.g. maternal sensitivity at 4.5 years → EF at 9 years; EF at 4.5 years → maternal sensitivity at 9 years; etc.). For treatment of missing data, full information maximum likelihood (FIML) was used in the analysis because it includes in the analysis all participants with missing data. FIML is a direct and superior approach over other alternatives such as missing completely at random (MCAR) and missing at random (MAR) (Enders & Bandalos, 2001).

3.4 Results

3.4.1 Study 1

For the preschool group, descriptive statistics and correlations are shown in Table 3.1. Rejection was significantly correlated with mother EF ($r = .54$, $p < 0.001$), and both child inhibition ($r = .40$, $p < 0.001$), and planning ($r = .40$, $p < 0.001$). There were no significant correlations between warmth and other variables. Between mother EF and father EF there was a moderated correlation ($r = .54$, $p < 0.001$); as well as between mother EF and child EF components ($r = .42/.51$, $p < 0.001$). Correlations between father EF and child EF were lower than mother EF and child EF ($r = .32/.22$, $p < 0.05$).

For the middle childhood group, descriptive statistics and correlation are shown in Table 3.2. Rejection was significantly correlated with mother EF ($r = .43$, $p < 0.001$), and with all child EF components ($r = .19 - .30$, $p < 0.01$), except for child shifting. Emotional warmth was negatively correlated with rejection ($r = -.24$, $p < 0.001$) and child shifting ($r = -.13$, $p < 0.05$). Mother EF was significantly correlated with father EF ($r = .42$, $p < 0.001$); and with all child EF components ($r = .40$, $p < 0.001$). On the other side, father EF was only significantly correlated with child inhibition ($r = .26$, $p < 0.001$), shift ($r = .21$, $p < 0.05$), emotional control ($r = .28$, $p < 0.001$), initiative ($r = .30$, $p < 0.001$) and planning ($r = .27$, $p < 0.01$).

Table 3.1: Bivariate correlations between parenting styles, parent EF and child EF of preschool children

	1	2	3	4	5	6	7	8	9
1. Warmth	—								
2. Rejection	-.17	—							
3. Mother EF	-.14	.54***	—						
4. Father EF	-.02	.19	.54***	—					
5. Child Inhibition	-.08	.40***	.51***	.29**	—				
6. Child Shift	-.02	.16	.38***	.32***	.38***	—			
7. Child Emotional Control	-.11	.30	.44***	.22***	.56***	.55***	—		
8. Child WM	-.03	.31	.48***	.25*	.70***	.41***	.48***	—	
9. Child Planning	.00	.40***	.42***	.25*	.58***	.37***	.44***	.77***	—

Note: EF = Executive function; WM = Working Memory.
$***p < .001$; $**p < .01$; $*p < .05$

Table 3.2: Bivariate correlations between parenting styles, parent EF and child EF of children in middle childhood

	1	2	3	4	5	6	7	8	9	10	11	12
1. Warmth	—											
2. Rejection	-.24***	—										
3. Mother EF	-.13	.43***	—									
4. Father EF	-.06	.29	.42***	—								
5. Child Inhibition	-.09	.30***	.24***	.26**	—							
6. Child Shift	-.13*	.22	.27**	.21*	.62***	—						
7. Child Emotional Control	-.10	.30***	.31***	.28**	.64***	.69***	—					
8. Child Initiative	-.12	.25***	.30***	.30***	.55***	.67***	.57***	—				
9. Child WM	-.11	.27***	.25***	.17	.66***	.64***	.58***	.73***	—			
10. Child Planning	-.12	.26***	.30***	.27**	.64***	.69***	.62***	.76***	.84***	—		
11. Child Organization	-.95	.19**	.30***	.15	.50***	.48***	.42***	.50***	.59***	.55***	—	
12. Child Monitor	-.08	.30***	.23**	.18	.72***	.69***	.63***	.65***	.72***	.80***	.535***	—
M	60.55	16.67	92.15	95.33	13.69	11.13	14.42	11.81	15.00	17.30	9.88	12.72
SD	5.23	2.81	14.95	16.24	3.71	2.76	3.95	3.12	4.36	4.88	2.89	3.38

Note: EF = Executive function; WM = Working Memory.
$***p < .001$; $**p < .01$; $*p < .05$

Mediator path analyses

For the first study we analyzed the association between both parent EF and child EF via both warmth and rejection. First, we tested whether there was a direct effect between both mother and father EF and child EF. In the preschool group, there was a significant association between mother EF and child EF ($\beta = .55, p < .001, SE = .08$) with fit indices suggesting an overall good fit of the model (χ^2 (9) = 30.67, p = .000; CFI = .9w; TLI = .86; RMSEA = .16; SRMR = .07). There was also a slight significant association between father EF and child EF ($\beta = .02, p < .01, SE = .10$) with fit indices suggesting an overall good fit of the model (χ^2 (9) = 23.53, p ¡ .001 = .01; CFI = .93; TLI = .88; RMSEA = .14; SRMR = .07).

In the middle school group, there was a significant association between mother EF and child EF ($\beta = .33, p < .001, SE = .08$) with fit indices suggesting an overall good fit of the model (χ^2 (27) = 61.26, p = .000; CFI = .96; TLI = .95; RMSEA = .100; SRMR = .03). There was also a significant association between father EF and child EF ($\beta = .28, p < .01, SE = .09$) with fit indices suggesting an overall good fit of the model (χ^2 (27) = 68.75, p = .000; CFI = .94; TLI = .92; RMSEA = .11; SRMR = .04). The significant direct pathway between both parents' EF and child EF in both groups indicates that there is a relation between parents' EF and child EF, stronger between mother and child than between father and child in both groups.

Second, we tested the role of parenting styles (i.e. warmth and reject) as mediators between both parent EF and child EF. Table 3.3 shows all fit indices for the mediated model. Fit indices suggested an accepted fit for every model.

All standardized betas for every model are shown in Figure 3.4. All pathways of both models analyzing reject parenting are significant with only one exception (Preschool group; father EF → reject). Emotional warmth parenting did not have a significant path for any relation between parent EF → warmth → child EF. In both groups, mother EF had stronger effects than the father EF, especially mother EF to reject path. Unstandardized coefficients are shown in Table 3.5

Table 3.3: Fit index for mediator effects

		Model	χ^2	*df*	χ^2/df	CFI	TLI	SRMR	RMSEA
Preschoolers	Reject	Mother	39.65***	13	3.05	.91	.85	.07	.14
		Father	32.31**	13	2.48	.91	.86	.07	.13
	Warmth	Mother	39.15***	13	3.01	.90	.84	.07	.14
		Father	28.84**	13	2.21	.92	.88	.07	.12
Middle childhood	Reject	Mother	74.85***	34	2.20	.95	.94	.04	.10
		Father	80.09***	34	2.36	.94	.91	.04	.11
	Warmth	Mother	65.87***	34	1.94	.96	.95	.03	.08
		Father	74.46***	34	2.19	.94	.92	.04	.10

Note: EF = Executive function.
$***p < .001$; $**p < .01$; $*p < .05$

Indirect effects are shown in Table 3.4. Significant direct effects were found in all paths between both parents EF and child EF, except between father EF and child EF via warmth in preschool group. Indirect pathway was only significant for mother EF → Reject → child EF in preschool group. The mediate effect is only partially explained because the significant pathway between mother EF and child EF was still significant.

Furthermore, suggesting that there could be another social factor involved in the previous findings, we conducted a follow-up analyses using parent level education to test for multiple group analysis in preschool group. We analyzed high and low maternal education (Mean= 4.24, SD = 1.86, range = 1-7). The analysis compared the fit of a model while a pathway was constrained. If the unconstrained model provides better fit compared with the other it suggests a difference between high and lowered levels of education. The results did not show a significant moderation across groups.

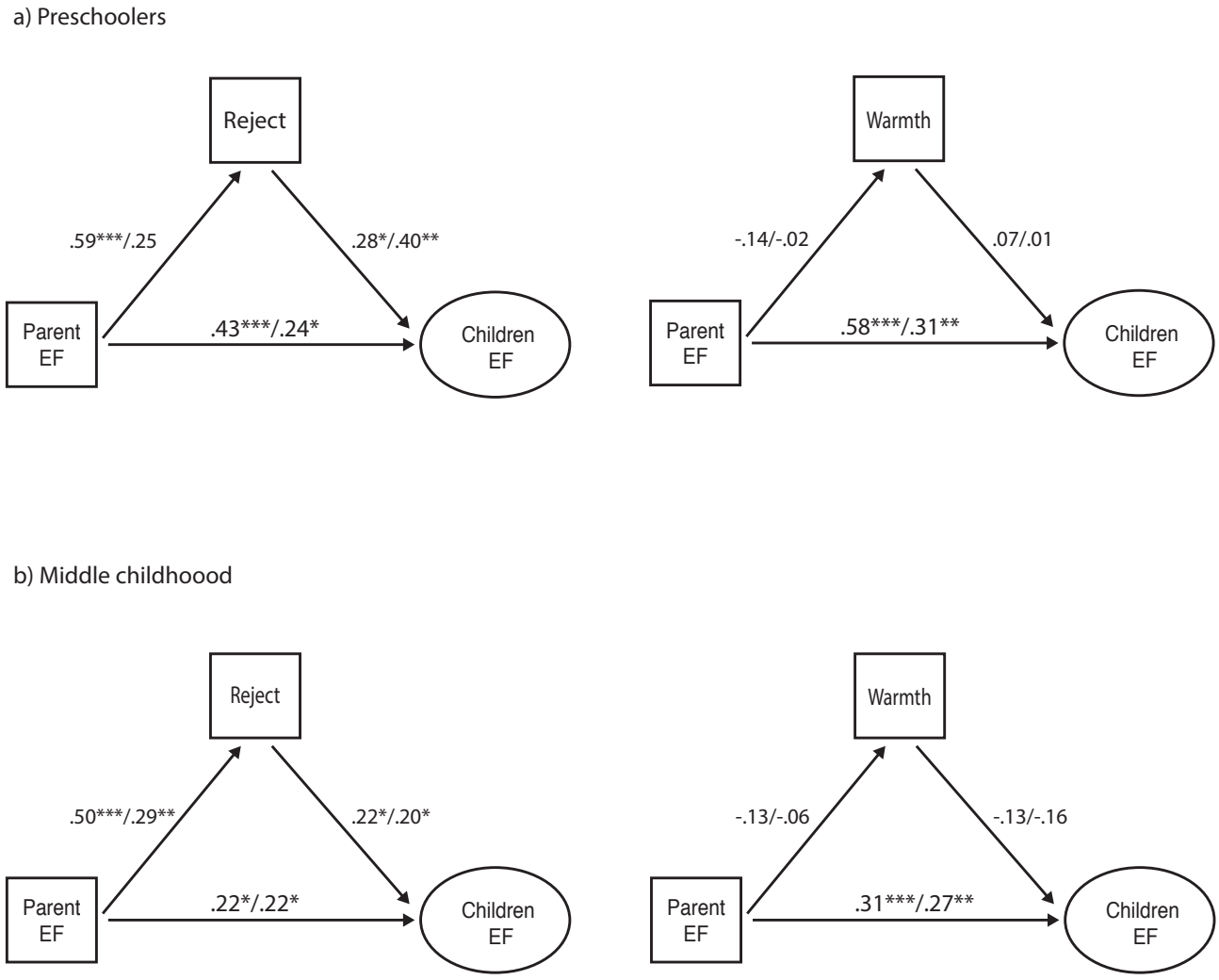

Figure 3.4: Path analysis model testing warmth and reject as mediators in the association between both parents EF and child EF.
Note: Standardized path coefficients are shown for mother on the left, and for the father on the right. $***p < .001; **p < .01; *p < .05$

Table 3.4: Mediator paths

Model	Path	Indirect	Direct
Preschoolers	Child EF → Reject → Mother EF	.16*	.43***
	Child EF → Reject → Father EF	.10	.24*
	Child EF → Warmth → Mother EF	-.01	.58***
	Child EF → Warmth → Father EF	.00	.02
Middle childhood	Child EF → Reject → Mother EF	.11	.22*
	Child EF → Reject → Father EF	.06	.22*
	Child EF → Warmth → Mother EF	.02	.31***
	Child EF → Warmth → Father EF	.01	.26**

Note: EF = Executive function.
$***p < .001; ** p < .01; *p < .05$

Table 3.5: Unstandardized values of mediate models

Paths	*B*	*SE*
Preschoolers		
Mother		
Mother EF → Child EF	.12***	.03
Mother EF → Reject	.12***	.02
Reject → Child EF	.38*	.18
Mother EF → Child EF	.16***	.03
Mother EF → Warmth	-.10	.07
Warmth → Child EF	.03	.03
Father		
Father EF → Child EF	.05*	.02
Father EF → Reject	.04	.02
Reject → Child EF	.49**	.18
Father EF → Child EF	.06**	.02
Father EF → Warmth	-.01	.06
Warmth → Child EF	.00	.03
Middle childhood		
Mother		
Mother EF → Child EF	.05*	.02
Mother EF → Reject	.10***	.02
Reject → Child EF	.23*	.11
Mother EF → Child EF	.06***	.02
Mother EF → Warmth	-.05	.03
Warmth → Child EF	-.06	.05
Father		
Father EF → Child EF	.06***	.02
Father EF → Reject	.06**	.02
Reject → Child EF	.21	.11
Father EF → Child EF	.06**	.02
Father EF → Warmth	-.02	.03
Warmth → Child EF	-.09	.03

Note: EF = Executive function.
$***p < .001; **p < .01; *p < .05$

3.4.2 Study 2

The second study was tested with the Bages' sample; refer to section 3.4.1 for descriptive and correlation analyses.

Direct effect

We analyzed the possible associations between warmth and rejection from both parents on child EF in both groups (i.e. preschool group and middle childhood group). The fit indices indicated that the models were accepted for the preschool group. Fit indices in middle childhood group reported a better fit. In Table 3.6 are shown the fit indices for both groups.

Table 3.6: Fit index for direct effects

		χ^2	*df*	χ^2/df	CFI	TLI	SRMR	RMSEA
Preschoolers	Reject	34.73***	9	3.86	.92	.87	.05	.15
	Warmth	53.39***	9	5.93	.90	.83	.06	.16
Middle childhood	Reject	83.51***	27	3.09	.95	.94	.03	.10
	Warmth	11.72***	27	4.14	.94	.93	.03	.11

Note: EF = Executive function.
$***p < .001$; $**p < .01$; $*p < .05$

Figure 3.5 shows the pathways associations between parenting style and child EF. Reject was significant related with child EF in preschool children ($\beta = .42, p < .001, SE = .08$), and in middle childhood group ($\beta = .32, p < .001, SE = .07$). The pathway between warmth and child EF was not significant in the preschool group ($\beta = -.05, p < NS, SE = .08$), but it was negatively significant in the middle childhood group ($\beta = -.13, p < .05, SE = .06$). Unstandardized coefficients are shown in Table 3.7.

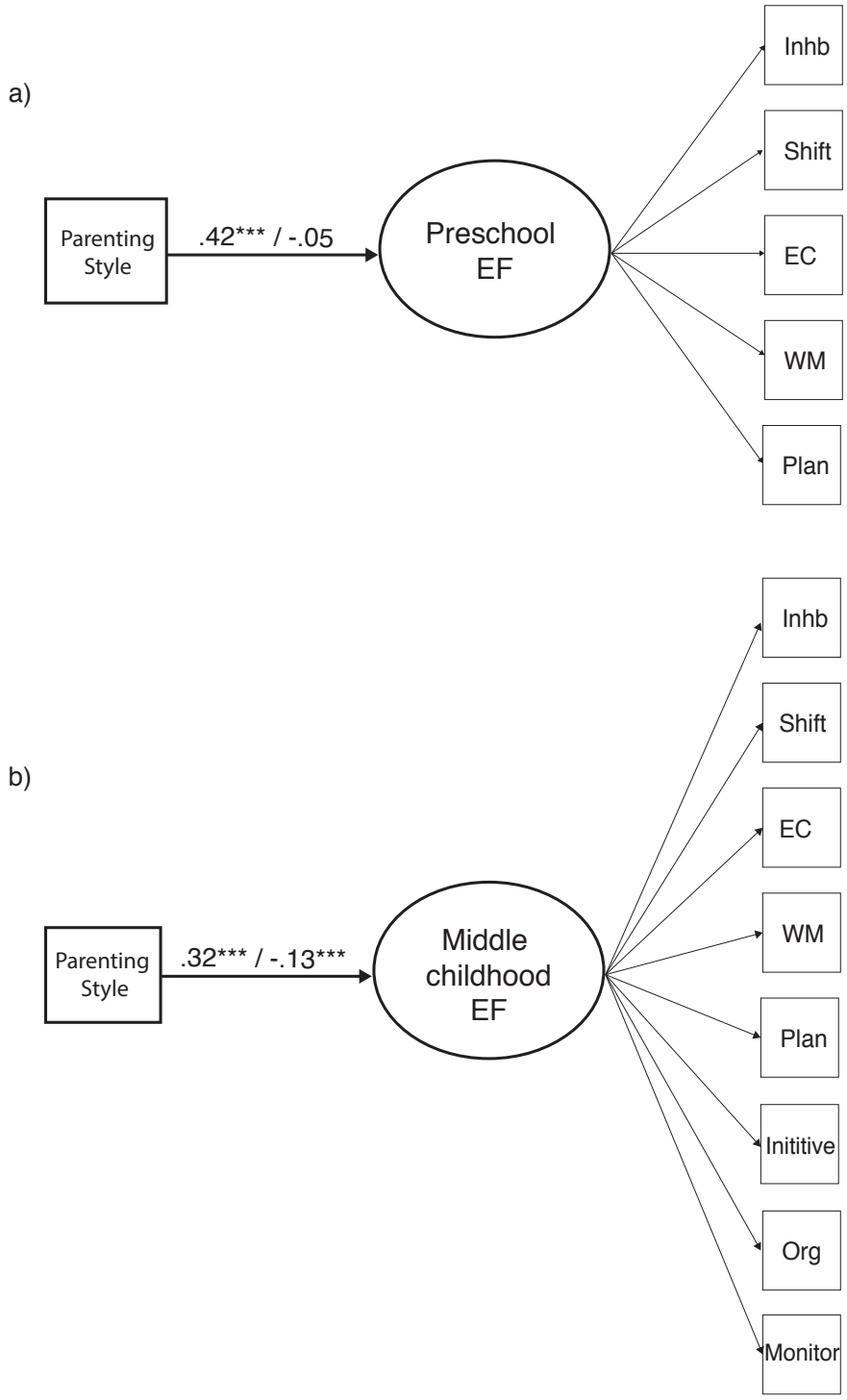

Figure 3.5: Direct models for both groups.
Note: a) preschool group; b) middle childhood group. Left value for reject SEM model, right value for warmth SEM model. Inhb = Inhibition; WM = working memory; EC = emotional control; Plan = planning/organizing; Org = organization of material. $***p < .001$

Table 3.7: Unstandardized coefficients for direct associations

Paths	B	SE
Preschoolers		
Reject → Child EF	.58***	.12
Warmth → Child EF	-.02	.03
Middle childhood		
Reject → Child EF	.32***	.07
Warmth EF → Child EF	-.07*	.04

Note: EF = Executive function.
$***p < .001; *p < .05$

3.4.3 Study 3

Cross-lagged model

Descriptive statistics on indicators in original scales are presented in Table 3.8, and bivariate correlations based on $z - score$ composites are presented in Table 3.9. Maternal sensitivity and EF were significantly positively associated at all three time points. Although, both variables at 15 years of age have a week relationship ($r = .13$, $p < 0.001$). All EF composite across assessment points have a strong correlation between one and another ($r = .44/58$, $p < 0.001$). Between maternal sensitivity assessments' the relationship was moderate ($r = .32/39$, $p < 0.001$).

The full cross-lagged model had excellent fit: χ^2 (2) = 2.80, p = .25; CFI = .99; TLI = .99; RMSEA = .02; SRMR = .01. Figure 3.6 shows the path diagram with standard regression weights. Unstandardized regression weights are presented in Table 3.10. Both maternal sensitivity and EF showed modest to moderate temporal stability of individual differences across the three waves. Three of the four cross-lagged paths were significant: maternal sensitivity at 4.5 years → EF at 9 years, EF at 4.5 years → maternal sensitivity at 9 years, and maternal sensitivity at 9 years → EF at 15 years.

We conducted a multiple group analysis to test for between-group variation in the model previously described (Figure 3.6). Two different group analyses were made: sex (male: N = 528: 50 %; female: N = 529: 50 %), and socioeconomic status (SES) (0 = Low [N = 658: 47.1%] and 1 = High [N = 658: 52.9%]). SES was composed of paternal education at 4.5 years of age and ration income at recruitment point (average scores were z-transformed and then averaged). Average maternal education was 14.23 (SD = 2.51, range = 7 - 21); for the fathers it was 14.49 (SD = 2.69 range = 6 - 21). Average ratio of anual family income was 3.59 (SD = 3.17, range = .10 - 56.97). The analyses were conducted comparing the fit of a model where structural paths were constrained to be equal across groups to establish measurement of invariance.

If the unconstrained model provided a better fit compared to the constrained model, it suggested difference between the groups. Results of the two multiple group analyses showed no

Table 3.8: Descriptive statistics for every variable in the longitudinal study

	N	M(SD)
Gender		
Male:Female (%)	1057	49.95:50.05
EF 4.5 years	1084	.00 (.68)
CBQ (mother) Attention focusing	1017	4.70 (.85)
CBQ (caregiving) Attention focusing	713	4.86 (1.03)
CBQ (mother) Inhibitory control	1054	4.67 (.76)
CBQ (caregiver) Inhibitory control	719	5.09 (1.08)
CBCL (mother) Attention problems subscale	1054	2.73 (2.39)
CBCL (father) Attention problems subscale	805	2.68 (2.38)
CPT - number of correct responses	1029	31.15 (10.05)
Woodcock Johnson - Standardized scores	1054	91.74 (18.49)
EF 9 years	1016	.00 (.71)
CBCL (mother) Attention problems subscale	1026	2.77 (2.89)
CBCL (father) Attention problems subscale	751	2.90 (2.85)
Woodcock Johnson - Standardized scores	1013	43.76 (4.33)
Tower of Hanoi - Total planning efficiency score	1012	17.17 (1.71)
EF 15 years	937	-.01 (.65)
CBCL (mother) Attention problems subscale	973	2.33 (2.88)
CBCL (father) Attention problems subscale	698	2.40 (3.04)
Tower of London - Number of total moves	913	32.39 (17.09)
Operation Span Task - Total Score	932	6.86 (1.05)
Maternal sensitivity		
Maternal sensitivity 4.5 years	1040	5.65 (.97)
Maternal sensitivity 9 years	982	5.45 (.83)
Maternal sensitivity 15 years	898	5.19 (.84)

Note: EF = Executive function; CBQ = Children's Behavior Questionnaire; CBCL = Child Behavior Checklist; CPT = Continuous Performance Task

significant moderation effects across groups.

Table 3.9: Bivariate correlations between child EF and maternal sensitivity composites

	1	2	3	4	5	6
1. EF (age 4.5 years)	-					
2. EF (age 9 years)	.58***	-				
3. EF (age 15 years)	.44***	.54***	-			
4. Maternal sensitivity (age 4.5 years)	.35***	.32***	.24***	-		
5. Maternal sensitivity (age 9 years)	.35***	.35***	.28***	.39***	-	
6. Maternal sensitivity (age 15 years)	.22***	.19***	.13***	.32***	.33***	-

Note: EF = Executive function composite.
$***p < .001$

Table 3.10: Cross-Lagged Path Model Summary for unstandardized values

	B	*SE*
Stability paths		
EF 4.5 → EF 9	0.55***	0.03
EF 9 → EF 15	0.42***	0.04
EF 4.5 → EF 15	0.17***	0.04
Maternal sensitivity 4.5 → Maternal sensitivity 9	0.32***	0.03
Maternal sensitivity 9 → Maternal sensitivity 15	0.24***	0.04
Maternal sensitivity 4.5 → Maternal sensitivity 15	0.23***	0.04
Cross-Lagged Paths		
Maternal sensitivity 4.5 → EF 9	0.13***	0.03
EF 4.5 → Maternal sensitivity 9	0.24***	0.03
EF 9 → Maternal sensitivity 15	0.04	0.04
Maternal sensitivity 9 → EF 15	0.08*	0.03

Note = EF = Executive function composite. $***p < .001; *p < .05$

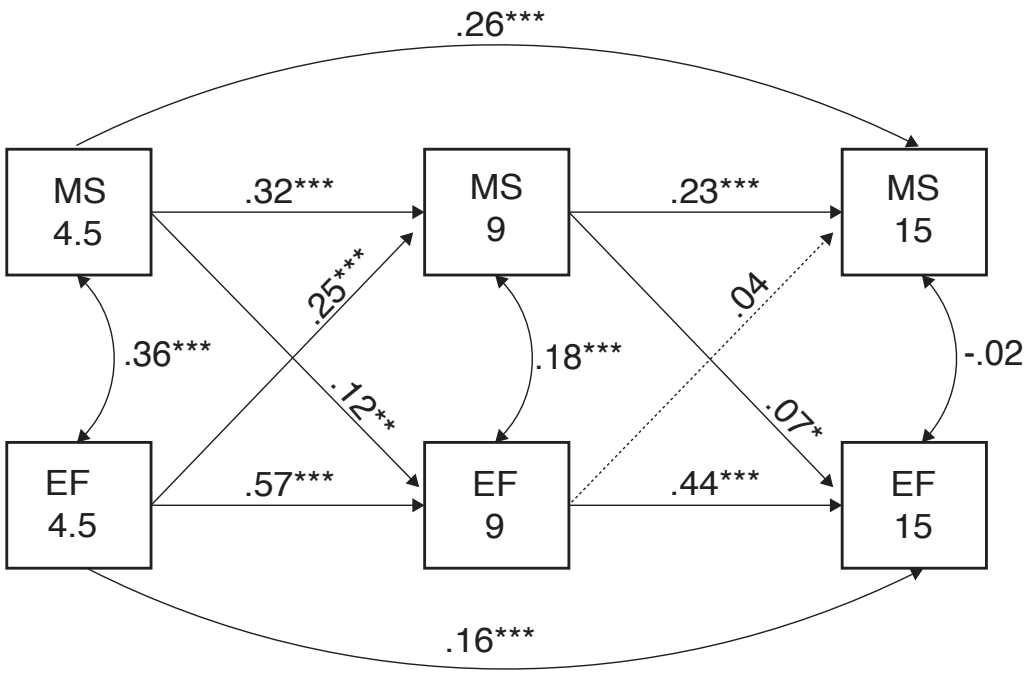

Figure 3.6: Cross-lagged path model of maternal sensitivity and executive function.
Note: MS 4.5 = maternal sensibility at 4.5 years; MS 9 = maternal sensitivity at nine years of age; MS 15 = maternal sensibility at 15 years of age; EF 4.5 = executive function at 4.5 years; EF 9 = executive function at nine years of age; EF 15 = executive function at 15 years of age. $***p < .001; *p < .05$

4 General discussion

The main objective of this thesis was to explore the relations between parenting styles and EF. Based on previous literature we designed three studies. The first study was focused on the mediated associations between both parents EF and child EF via two parenting styles (i.e. emotional warmth and rejection). The second study was designed to explore the relations between both emotional warmth and rejection, and child EF. And finally, the third objective was focused on the longitudinal effects of positive parenting (i.e. maternal sensitivity) and child EF. In order to analyze those objectives, we used one sample from Spain and a data set from U.S. The main results draw attention to the importance of both parenting styles (i.e. positive and negative) on child EF; highlighting the influence of rejection as a mediator in preschool children, the strong association between rejection and child EF, and the bidirectional-long-term-effects of positive parenting on child EF.

Study 1

The first objective was structured to partially replicate the mediated findings of Cuevas et al. (2014). With the Bages sample we analyzed the cross-sectional relations between both mother and father EF, and child EF. First, we estimated the association between each individual mother and father EF, and child EF. Then, we analyzed the mediated relations between both mother/father EF and child EF via two parenting styles (i.e. emotional warmth and rejection). The results showed that only in preschool children, rejection mediated the relation between mother EF and child EF. The correlations were significant between mother EF and rejection in both groups (i.e. preschool and middle childhood); however, when testing the mediation models, the results revealed that only the links between maternal EF and child EF in preschool children were partially mediated by rejection. Those results were not significant in the case of the father

for both groups.

Cuevas et al. (2014) studied the contributions of maternal EF, negative caregiving behaviors, and child EF in a longitudinal study with children at 24, 36, and 48 months of age. Our results showed similar findings projecting that negative maternal rearing (i.e. rejecting) partially mediated the link between mother EF and child EF. Even when we tried to explore it in the analysis of later ages, emotional warmth (i.e. as opposite of rejection) and father EF, the only consistent finding was partially mediated relation between mother EF $\rightarrow$ rejection $\rightarrow$ child EF. In this sense, our results were supported by Cuevas et al. (2014) study, suggesting that harsh and difficult caregiver behaviors play an important role within the transmission of EF between mother and child.

To account for other socio-factor components we control for maternal education level; there was no difference between high and low education level. We were expecting that given the low education range of the mothers, this results might differ from one group to another. However, the non significant difference could be the result of a lower percentage of mothers with high education levels (i.e. bachelor degree, college). With a more homogeneous group the difference between both groups could be more substantial.

It is important to mention that a first step for the analysis was to test the relation between both parents' EF and child EF. The results of such models showed that beta coefficients were much stronger between mother EF and child EF than between father EF and child EF in both groups. Also, in preschool children the gap between mother EF/child EF and father EF/child EF is even larger. The betas in the middle childhood group between those relationships do not differ as much as in the preschool group.

It is possible that father EF is not involved in this relation because of two major aspects; the first one is that the father is not the primary caregiver, and secondly, because of genetic associations with the child. The role of the primary caregiver could be essential for parent-child EF social transmission (Baumrind, 1967), especially in younger ages, when the child is more

vulnerable to internal (i.e. brain plasticity) and external changes (i.e. parenting style) (Zelazo & Carlson, 2012).

The strong relation between mother EF and child EF could be explained by the result of an intense, interactive and continual training of the child by the primary caregiver. Because of the basic needs of younger children (e.g. feeding), the role of the mother is highly important during that age, which results in a closer relationship between the two of them. The father, however, plays a secondary role where he is not as involved as the mother with caring behaviors. Therefore, we suspect that the strong attachment between mother and child could determine different outcomes on child well-being, relating to this study, those outcomes can define child EF.

The conception of the mother as a primary caregiver comes from cultural-social values, which dictate the mother as an icon of providing her child with all their immediate needs. Hence, the stereotype of the father involves authority, structure and monetary stability. Particularly, Spanish families exercise a strong role based on the woman, where family functions go through them in a cultural and affective way (Brøgger & Gilmore, 1997). In this sense, Spanish mothers have a more influential role on the children than fathers. Culturally, this could be true at later ages as well (not only at younger ages), where children are less dependent on mother rearing practices. Considering this, EF relation between parents and children may take place because of daily practices: if this hypothesis is accurate, in cultures where the father is more involved in child rearing practices the results might be quite similar for both parents (Osiek, 2008).

Even when our study did not account for genetic relations between EF it is an issue we must address. The genetic transmission plays an important role in this relation. N. Friedman et al. (2008) found in a multivariate twin study that EF are influenced by genetic influences, placing EF as one of the most heritable psychological traits. Studying father influences -or even the mother's-, without a DNA test, makes us vulnerable to not be able to understand the whole spectrum of relations between both parents EF and child EF, as is the case with our

study. However, considering this limitation, we could assume that the probability of genetic transmission in our study is higher for the mother than the father, simply because -the chances are higher- that the mother gave birth to the child.

We consider that for now, this limits our knowledge to actually distinguish between environmental changes and genetic EF transmission. However, the reaches of this study are confined to understand how parenting styles could influence EF relation between both parents and their child, not only in the transmission of EF.

The results of this study provide information about how day-by-day interaction between mother and children could be influenced by a harsh-reject parenting style. This finding supports the idea that possible genetic transmission of EF, child brain development, and an adverse environment are interdependent with each other. Mother EF and child EF transmission occurs at the moment of conception; child brain development occurs organically throughout the child's life and an adverse environment, such as rejection as a parenting style, appear to affect those transmissions. If those relations are related in that way, we can suggest that the quality of the parenting style provided by the primary caregiver is highly important at a younger age, when it comes to EF. All interrelated factors could influence the EF transmission between mother and child very harshly.

Study 2

The second study was targeting a comparison between both negative and positive parenting styles and child EF. The results showed a stronger relation between rejection and child EF in both groups. The relationship between warmth and child EF was only significant in the middle childhood group. Within these findings we account for a stronger relationship between rejection and child EF than between warmth and child EF. This evidence is relevant because at this point, no studies have compared the relation of both parenting styles and child EF in older children.

The strong relationship between rejection and child EF has been previously reported by other

studies (Cuevas et al., 2014; Deater-Deckard et al., 2009, 2012). It is also partially supported by Hughes and Ensor (2006), where they found a strong correlation between both variables in 2-year-olds. The literature related to this subject is relatively new and somewhat limited, however most of the studies have focused on the effects of negative environment on child EF (e.g. Talwar et al., 2011). According to Barrett and Fleming (2011) there is a consistent finding of the relationship between abuse or neglect and child EF. Barret and colleagues also suggested that early adversity has been linked to EF and specific EF components (i.e. problem solving, working memory, inhibition and attentional control). Overall, our results showed a strong association between rejection and child EF in both groups. This finding could be interpreted as the strong-immediate reaction of the child to harsh environments.

Previous studies reporting the effects of negative parenting styles on child development have consistently found a strong relation with externalizing behaviors (Bradley & Corwyn, 2007). According to our results, negative rearing practices might also affect cognitive aspects, such as EF. Those relations between parenting styles and both child EF and child externalizing behaviors might be something to consider for future studies. We consider that those negative parenting practices might be a key factor to explain the possible cognitive impairments, such as low inhibitory control, in children with externalizing behaviors (i.e. oppositional defiant disorder and conduct problems) (Brophy, Taylor, & Hughes, 2002)

Furthermore, our results showed a stronger association between negative parenting style and child EF in preschool groups than in middle childhood; this could be explained by the vulnerability of brain plasticity at younger ages (Zelazo & Carlson, 2012). Another possibility to explain this difference is with a social approach. It is possible that younger children might be more susceptible to external environment because of the close co-dependent relationship with the primary caregiver as a social agent. Given those possibilities, we suspect children at early ages are especially vulnerable to harsh environments, where the mother reacts to them in a harsh-difficult-reject way. In middle childhood, the child becomes more independent and is involved in a more social context (e.g. peers, teachers, other family members). In this sense, the

close-relationship between mother and child at younger ages might have an immediate effect on child EF and as years goes by, those effects might diminish slightly.

The association between positive parenting practices and child EF at a range between 5 and 16 years old, has been previously reported in cross-sectional studies (Samuelson et al., 2012; Schroeder & Kelley, 2010). However, we were expecting to find such relations in preschool children, as others have reported (Blair et al., 2014; Bernier et al., 2010; Kok et al., 2014; Von der Lippe et al., 2010; NICHD Early Child Care Research Network, 2005). This inconsistency might be the result of comparing cross-sectional and longitudinal studies, or the difference between positive parenting practices (e.g. warmth, maternal sensitivity, control). In the overall discussion we expand on this argument.

The strong difference between both parenting styles and their relation to child EF opens up a discussion about how rearing practices might affect child well-being. These findings could be interpreted as the adversity where children are exposed when raised with harsh and difficult parenting practices. In this case, child EF in both groups are affected by rejection in a conclusive manner. However, emotional warmth parenting practices appeared to not be as involved in child EF as we originally considered. As we mentioned in the first study, we were expecting to find an adverse effect of rejection, and an enhancing effect of emotional warmth. Those expectations were not conclusive. It appeared that in this sample the results do not showed a cleared inverse relation with child EF. This could mean that rejection and emotional warmth are not necessary opposite dimensions divided in positive and negative parenting practices, but two different dimensions of parenting styles.

Study 3

In the third study, we analyze temporal stability and reciprocal relationship between maternal sensitivity and child EF in children from 54 months-old to 15-years-old. We found relative stability of maternal sensitivity and child EF from 4.5 to 15 years of age. Maternal sensitivity

and child EF were expected to be reciprocally related to each other over the three points of assessment. However, the significant effect between the two variables was found only between preschool ages and middle childhood, and not between 9 and 15 years old.

A substantial contribution to the literature from our findings is focused on firmly establishing the relation between EF and positive parenting in the first 15 years of life. There are few other attempts to get similar findings and are either focused on children's inhibition between 2 to 8 years of age (Roskam et al., 2014) or a cross-sectional study in children between 7 and 16 years of age (Samuelson et al., 2012). However, in this study we evaluated several components of EF in a longitudinal study for several years. The cross-lagged model allow us to interpret both paths from child EF and parenting practices, which according to our results those relations are maintained from early childhood to adolescence.

The bidirectional effects between maternal sensitivity and EF in early ages had been reported several times (Bernier et al., 2010; Blair et al., 2014; Kok et al., 2014; NICHD Early Child Care Research Network, 2005). Specifically, the findings in this study suggest that before middle childhood, higher levels of child EF appeared to promote maternal sensitivity, while high levels of maternal sensitivity predict fewer deficits of EF. This bidirectional effect could produce a positive bidirectional interaction that becomes more pleasurable and reinforced throughout the first years (Waller et al., 2014). However, the interaction between middle childhood and adolescence becomes only significant between maternal sensitivity and child EF, and this pathway seems to diminish when comparing to previous years.

One way to explain this is through social interaction. Before preschool years, the most social proximal interaction of children is the mother; as the years go by, teachers and peers become an important influence on the child's social context. The possible effects of daily routines imposed by the parents probably start to slightly vanish as the adolescent becomes more independent. According to our findings, the effects of parenting on EF could be present until middle childhood and between puberty and adolescence those predictors become less robust. It is also possible

that within these results, we could account for how social interactions (like parenting) might have an effect on child EF. These results also ensure the possibility that children are extremely vulnerable to different environments, in this case it is a positive-supportive environment that help them to develop better EF skills.

Another possibility is related to EF literature establishing a relation between frontal lobes and EF performance; especially when considering the maturation of the frontal lobes between middle childhood and adolescence (Welsh & Pennington, 1988; Welsh, Pennington, & Groisser, 1991). Research in the field has reported an important growth in multiple regions of the prefrontal cortex, especially with myelination and synaptic pruning (Blakemore & Choudhury, 2006; Steinberg, 2005). During this period, brain maturation continues in the fronto-parietal systems within the superior temporal sulcus (Paus, 2005).

Within this context, in our assessment of EF involving problem-solving activities, we used laboratory tasks such as the Tower of Hanoi and the Tower of London at the age of 9 and 15 years old, respectively. In fMRI studies, those tasks have been related to the prefrontal cortex (Newman, Carpenter, Varma, & Just, 2003; Newman, Greco, & Lee, 2009). In this sense, we suspect that prefrontal maturation between middle childhood and adolescence could be a key factor explaining the diminishing effect between maternal sensitivity and child EF in our cross-lagged model. It appears that on those developmental changes, maternal sensitivity does not play a key role in child EF as was showed in younger ages.

Furthermore, our results suggest developmental stability of EF and positive parenting practices through child's 4.5 years of age until 15 years old. According to our results, it is possible to predict the mother's sensitivity and child EF at 15 years old, when the child is 4.5 years of age. Miyake and Friedman (2012) and N. Friedman et al. (2011) support this stability related with EF. Both studies reported EF stability with respect to individual differences across several points. Our results are consistent with those findings supporting the EF stability across our three points.

The literature on maternal sensitivity stability is not so consistent; Metzler, Biglan, Ary, and Li (1998) found in a six months time-lapse, with children from 5th to 7th grades, a relative stability across assessment points. Dallaire and Weinraub (2005), using NICHD SECCYD data set, found similar results in the first six years of life. Those changes through time in parenting practices might be the result of different factor components. Stress, household chaos, and SES are some of the factors involved in parenting practices.

The difference between EF and maternal sensitivity stability across points might be the result of different ontogenies. EF have been assumed to be related to brain development maturation, while parenting practices have been related to an environment change, dependant on psychosocial factors (Gonzalez, 2015). Those major differences provide the opportunity to understand that parenting practices can be modified through different factors. Considering all the risk factors and how to promote better parenting practices it could be more adequate to promote better EF child development.

Considering demographic effects, our results did not find a moderator effect of SES and gender on the cross-lagged model. Similar findings on gender differences have been reported in the NICHD Study (Bernier et al., 2010). In other community samples, strong covariates on gender differences have been reported, although maternal education does not have any further effects (Bernier et al., 2010; Blair et al., 2014). While maternal education and ratio income are considered demographic risk factors, in this study SES played no part in the relation between maternal sensitivity and child's executive function. This is probably due to the fact that the data set used for this study was mostly a no-risk population. The NICHD Study does not have a good representation of economically disadvantaged families, even though efforts were made to extend the data set (Belsky, Schlomer, & Ellis, 2012). Those demographic effects were considered in order to understand a better socio-economic environment of the sample, however, we conclude that this no-risk sample is not considered modified by those variables.

Overall discussion

This thesis was considered because of the need for understanding how the relation between EF and different parenting styles evolve and interact. The results showed the highly important role of EF in an integrated system; involved with the transmission of EF between mother and children, with the positive or negative relations to child EF, or with the bidirectional paths in long-term effects. Previously we discussed some of the specific findings of every study. In the following section we are going to discuss the overall findings of the research.

The three studies involved in this thesis help to have a better understanding of the trans-generational transmission of individual differences of EF and parenting styles. The theoretical framework of the studies were based on Belsky's evolutionary theory; in which the social interaction is a process that transmits from generation to generation (Belsky, 1997). Geary (2006) referred that evolutionary developmental psychology represents a frame of reference to understand developing and potentially evolving behavioral, social, cognitive and physical phenotypes.

Developmental pathways of reproductive strategies reported by Belsky (1997) provide a good example of how family context, childrearing, psychological/behavioral development, somatic development, and finally reproductive strategy are dependent on each other; producing an understanding of how generation after generation families are going to reproduce their own parenting practices. For that reason, it is important to consider how the quality of parenting practices can affect child development. Our results enhances the influence between parenting styles and EF, in which daily routines and day-by-day learning opportunities occurred according to the quality of parenting practices.

The trans-generational transmission can be also understood within the models of Deater-Deckard (2014) and Gonzalez (2015). The transmission of early experiences to the child, parent responses, cognitive and emotional capacities, and home/family context are some important aspects to consider. Both models considered the role of EF as an important link between the overall system. The second study evaluated both parents EF relation with child EF and the possible effects of parenting styles. It appears that there is a strong relationship between child's

and parent's EF; insinuating the possible trans-generational transmission within one generation to another. In this case, we could assume that positive or negative effects could be reflected from to subsequent the subsequent generation.

Assuming this evolutionary framework, it is possible to conceive of the idea that trans-generational transmission of EF might take place. According to the results of the three studies, there is not only a biological development of EF characterized by prefrontal cortex development and genetic transmission, but it also depends on social environment (i.e. parenting practices). Within this instance, the quality of caregiving behaviors would affect parent-child EF transmission generation after generation, causing poor EF or good EF performance within families. The consequences of those generational pathways could define families' histories, such as dropping out of school at younger ages, aggressive behaviors, failing or succeeding to maintain a job, good grades, assertive management of emotions, and empowering jobs.

The success of programs training parents, such as incredible years of parenting (Webster-Stratton, 2011), are having a positive effect in improving the quality of parenting behaviors, preventing behavior conduct problems (Reid, Webster-Stratton, & Hammond, 2003) and improving social and emotional competence (Webster-Stratton & Reid, 2004). In the case of EF, we proposed that the training program for parenting might have an effect on EF development. Given the opportunity to break a socio-emotional cycle of trans-generational transmission of poor EF performance and enhance a good EF development.

One more thing to discuss is the difference between the second and third studies. In the second study, we found a significant relationship between warmth parenting and child EF only in the middle childhood group and not in preschool children. In the third study our findings suggest a stronger relationship between maternal sensitivity and child EF. This mismatch between both samples could be explained because of the quality differences between maternal sensitivity and emotional warmth and also because of the differences between EF measurement.

The quality differences between positive parenting style (i.e. emotional warmth and maternal

sensitivity) could determine different effects on early young ages. Emotional warmth refers to an expression of love from the parents (Baumrind, 1996), including affection or praise contingently. Parental emotional warmth from the EMBU questionnaire has been related to parental attachment (Mothander & Wang, 2011; Perris & Andersson, 2000). While maternal sensitivity, according to Behrens, Hart, and Parker (2012), represents a generalized interactive behavior with her child rather than a unique response of a particular behavior. The NICHD SECCYD sample used a composite from supportive presence, respect for child's autonomy and low levels of hostility. The same composite of maternal sensitivity used in this research work has been related to attachment (Steele et al., 2014; Thompson, 2008) and cognitive processes (NICHD Early Child Care Research Network, 2005).

High scores of positive parenting are related to child development wellbeing; however, research of maternal sensitivity has provided a link to EF (Blair et al., 2014; Bernier et al., 2010; Kok et al., 2014; Von der Lippe et al., 2010). It could be that a warmth response to child EF development is important, but not enough in early ages. On the other hand, maternal sensitivity could provide a consistent and more accurate day-by-day training to the child, that could determine a better adjustment for every EF component. However, within these results a longitudinal analyses is needed to ensure that explanation.

The three parenting styles evaluated in these three studies give the opportunity to discuss a critical issue. We first considered that there were two main aspects of parenting styles: positive and negative (Hughes, 2011). Warmth and sensitivity was considered part of positive parenting practices and reject of a negative rearing. The results of the three studies do not support this main division; even when there is an inverse correlation between emotional warmth and rejection: when it comes to child EF relations the results are not as inverse as we would expect them to be between both groups (i.e preschoolers and middle childhood). This is also the case of the findings relating emotional warmth and maternal sensitivity.

Those mismatches between the effects of positive and negative parenting practices on child

EF redirect our first conception. Even when at the beggining we assumed that parenting styles were either "good" or "bad" because of the main characteristics of the dimensions, such as love, care, responsiveness, or harsh punishment and tone. However, when it came time to investigate such effects on child development the results are not as opposite from one dimension to another (Choe et al., 2013; Hinnant et al., 2013; Tung & Lee, 2014). The only exception comes from externalizing behaviors, where inductive discipline and warmth were associated with externalizing behaviors (Eisenberg et al., 2005) and harshness predicts otherwise (Bradley & Corwyn, 2007). It is possible that different dimensions as Baumrind (1967, 1980, 1996) assumed in her work, are necessary to further research on parenting styles. Further research is needed to have a better understanding on this subject, individual differences of children responses to parenting practices are a critical issue that would allow us to better understand the effects on child wellbeing, psychopathologies, cognitive process and behaviors.

Another thing to discuss around this research work is EF assessment. EF was measured with the BRIEF questionnaire for the first and second studies and for the third study an EF composite was structured with laboratory tasks and questionnaires (i.e. CBQ and CBCL) . Both forms of EF assessment have been previously evaluated in several studies, BRIEF questionnaire has been a useful tool to measure EF (Isquith et al., 2005); while the EF composite has been used by(Holmes et al., 2015). As it was mentioned, there is not a unified way to assess EF, several studies have used laboratory tasks to measure specific EF components (Welsh & Pennington, 1988), while others are targeting a more ecological measure of the EF (Gioia et al., 2008). According to our results, both ways could determine a useful validated way of measuring such a complicated construct as EF. Using the BRIEF questionnaire works as a screening process to collect major amounts of information. Laboratory tasks help to understand and measure in a specific and controlled manner every EF composite. The reasons for choosing one or another would depend on every study, however we could assume that both ways are useful once the limitations of every assessment process are taken into account.

To study something as complex as family environment and cognitive processes nowadays is

as innovative a challenge as one can be. This thesis tried to explore the relationships between family environment and EF in both studies. We concluded that positive and negative parenting can be related to child EF and also that negative parenting plays an important role on mother EF. There is no right answer to explain how environment, genes, or both, play a role with each other. Therefore, the study is still to be continued. Individual differences on child development, family environment, and parenting styles are research areas that at some point would work as preventive interventions; but in this case, we were trying to explore beyond that breach.

How could we enhance child wellbeing? As one could expect, harsh or physical punishment, parental rejection or reward inconsistency could have an immediate effect on the child. But what about over cared, over protected or over controlled? Those forms at some point could be understood as positive parenting and could affect the child's well being. Studying the relationships or effects of positive parenting style could help to understand, prevent and enhance child development in all social and cognitive areas.

Finally, the purpose of this thesis was to further understand a complicated subject. Given the novelty of the area our objective was to explore more about how EF and parenting interact with each other. According to our results, EF plays an important role within family context, whether influencing the quality of parenting practices or the effects on child EF. Either way, there is still more to know and understand about this subject and the limitations of this thesis are something to consider for further research.

5 Clinical implications

Considering that environmental changes can determine future development of EF, the clinical implications of this research work are confined to those terms. Our results showed an important relationship between parenting styles and EF. According to this, improving the quality of rearing behaviors we might as well change child EF development at younger ages. Parenting training programs are helping parents behave accordingly and responsively to their child's behaviors.

It is possible that if mothers are trained in developing sensitivity responses to their child, which include mutual respect, supportive responses and lower limits of hostility, could be beneficial to child EF in younger ages. Those ages are highly vulnerable to an established linear and substantial EF pathway through the years to come.

On the other side, parenting programs that would focus on diminishing hostility, harshness, rudeness, and rejection of the parent could be extremely beneficial to the trans-generational transmission of EF from mother to children. In those cases the relationship between mother EF and child EF would not be diminished because of a negative parenting practice.

Overall, the clinical implications of this research work are focused on clarifying the need to train parents to be better at parenting. Not only in at-risk populations, but also in community samples that can improve and take advantage of it. This can also be beneficial due to simple programs that would help their child wellbeing. That small change might help children not struggle in school, homework, or emotional relationships. With these parenting programs we could diminish over-reactive behaviors and children could be able to make better choices. Those changes in one generation, might help the next one.

6 Limitations and future directions

Within the work of this thesis there are some limitations to keep in mind. Given that we studied two different samples from two countries we were not be able to analyze with the same instruments. This methodological limitation confined the boundaries of the results.

Furthermore, there are several ways to assess EF. We evaluated the EF of the Bages' sample with a questionnaire (i.e. BRIEF), while for the NICHD SEECYD sample we used laboratory tasks and questionnaires. Using both samples help to review the different ways to assess EF and the use for each one in order to evaluate it. However, as it was discussed previously, there is no unified consensus of how EF should be measured. In this work we performed latent variables and EF composite in order to control some of the variance lost on the analyses, but to improve this work it is necessary to compare both samples in similar ways to assess the chosen variables.

For future directions there are other variables to keep in mind. Household chaos (Crandall et al., 2015) and stress (Deater-Deckard, 2014) have been two mediated variables for trans-generational studies. Both variables have been reported to have an effect on parents' well being and child development. Although this is a new research area, those variables appeared to play a role within the interaction of the family, but still more evidence is needed to back up such conclusions.

7 Conclusions

To conclude this research work we established the following conclusions:

- EF development is vulnerable to social environment, especially at younger ages.
- EF transmission between mother and child can be mediated by the rejection of the mother.
- The effects of rejection on child EF are stronger than emotional warmth.
- Bidirectional effects of maternal sensitivity and child EF diminish through time.
- The close relationship between mother and child plays an important role in child EF through time.
- The quality of parenting practices determine child EF from preschool to middle school, especially in preschool years.
- There is a strong possibility that positive parenting will enhance child EF development and on the contrary negative parenting practices might affect it.
- Positive parenting styles might have a long-term effect on child EF, while negative parenting styles have an immediate effect.

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