



Mother-infant co-regulation from 0 to 2 years: The role of copy behaviors. A systematic review

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ABSTRACT

The purpose of this review was twofold: (1) to examine how copy behaviors (CB) have been studied in mother-infant natural interactions from 0 to 24 months, and (2) to determine to what extent they can be considered co-regulation processes between both members of the dyad. To do this, 36 studies published between 1975 and 2021 were systematically examined, classified and discussed. The analyzed evidence showed that CB in spontaneous mother-infant interactions have been examined under different perspectives, that such behaviors might be differentially classified as distinct modes of copying according to their traits and, lastly, that CB operate as social facilitators that foster the co-regulation of both affects and behaviors and direct mothers and infants, most of the times, towards a mutual sense of interpersonal matching that adds quality to their interactions.

1. Introduction

Copying other's actions in dyadic exchanges with caregiving figures is one of the main things that infants do in their first two years of life. Infants copy for learning not only bodily movements, acts on objects, or with the intention of achieving material goals, but to acquire abstract rules and strategies, social, communicative, and affective-regulation competencies (Rogers & Williams, 2006; Uzgiris, 1981). Copy behaviors (CB) are crucial for cultural propagation, causal learning, social-emotional interaction, and the development of a theory of mind (Meltzoff and Williamson, 2013; Nielsen, 2009). Cultural exchanges provide the infant the opportunity to imitate significant social partners, whose contingent and responsive actions are recognized, as Meltzoff and Marshall (2018) have proposed, as "like me" experiences by the infant. Besides, adults reciprocally copy infants' behaviors and enrich them with additional modeling activities. As a result, co-regulation processes emerge within their interaction moments, giving rise to a particular pattern of communication and correspondence between them very early in development.

The research on CB has a long tradition and has led to important debates, from their ontogeny to the name that different authors have used to describe them. Scientific efforts have resulted in a lively body of literature that has aroused diverging perspectives: there are opposing discourses about whether the ability to imitate is innate or not (Meltzoff and Moore, 1977; Heyes, 2016; Oostenbroek et al., 2016); some authors have studied copying more as a cognitive act while others have emphasized its socio-communicative aspect (Horner & Whiten, 2005; Over, 2020), and it also appears that the same type of behavior is not always behind the word "imitation" (or

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others; e. g. “mimicry”, “matching”, “mirroring”, etc.) (Want & Harris, 2002; Whiten et al., 2004). Therefore, it seems that there are several ways in which CB can manifest throughout infancy, and they might fulfill different functions (Nieto & Campos, 2021). This might mean that perhaps their contributions to the characteristics of interpersonal interactions may also be differential.

Nevertheless, all kinds of CB are an ideal platform for learning, testing, and training new skills, shared social schemes and communicative aptitudes in the early years (Carpenter, 2006; Charman, 2006; Uzgiris, 1984). For example, intentional *imitation* (Boesch & Tomasello, 1998; Tomasello et al., 2005) serves an instrumental function that is key for learning procedures and developing motor and cognitive abilities during infancy (Elsner, 2007), by copying both the goal or result pursued and the intentional states and actions of the model (Tomasello & Carpenter, 2005). For its part, *emulation* would consist in achieving the same outcome observed on a model without precisely reproducing the exact same techniques used in the first place (Fridland & Moore, 2015). *Mimicry*, a low-level interpersonal copying phenomenon that occurs when an individual spontaneously and unconsciously copies the behavior of another person, has been described as a “social glue” due to its affiliative phylogenetic function (Lakin & Chartrand, 2003). Overall, the occurrence of CB fosters not only the acquisition of skills but also a sense of mutuality, interpersonal bonding (Stern, 1985), tuning and identification with the others (Meltzoff & Marshall, 2018). All of this enables the learning of socially constructed norms and conventions (Over & Carpenter, 2013) and lays some important foundations for human socio-communicative development.

Infants’ first cognitive, social, and affective learnings occur in the context of dyadic interaction. Throughout their first two years of life, the most relevant affective connections are those that children establish with their main caregivers. In most cultures, this adult figure is mainly represented by their mothers (Bowlby, 1969). The idea of the dyad as a context or scenario is posed because the *mother-infant system* must be deemed as more than the sum of its parts—meaning that it is not reducible to the simple addition of parents’ actions plus infants’ responses or vice versa (Kaye, 1982). There are bidirectional effects that, together with a shared history and the commonality of goals pursued by its members, give the dyad an entity of its own and make it worth it considering it as a unit. In line with these ideas, it is the experience of mutuality facilitated by CB that adds quality to the dyad’s attachment bonds (Trevanthen & Aitken, 2001). Also, the unique features and climate that emerge in the context of the dyad make it more likely for infants to engage in CB (Sauciuc et al., 2020).

As a result of this, CB lead to several co-regulation processes between infants and their main caregivers, since they represent a type of exchange in which the actions of one individual are directly influenced by the ever-changing actions of his/her partner (Fogel, 1993). As co-regulation facilitators, CB have been described as good evidence of positive, mutual interactions, and are also a potential indicator of the caregiver’s awareness to the child’s needs (Campos & Nieto, 2017). Co-regulation goes beyond individuals, involving the dyad’s relational patterns that emerge through interpersonal interaction and the continuous regulation of the other’s behavior and emotion (Fogel, 2000). The occurrence of certain CB during infancy, as happens with other communicative interactions (Beebe et al., 2016), is not always symmetrical. For example, overt imitation is primarily displayed by the caregiver figures whose responses are intended to fit children cues and eliciting their subsequent behavior. However, this imbalance fluctuates between one and another member of the dyad throughout development (Stern, 1974): infants have the ability to influence their mothers’ behaviors through copying from early on (e. g. by mimicking their gestures), and this effect increases as they improve their skills to use CB as intentional and communicative tools contingent upon their own interest (e. g. displaying voluntary, goal-directed copies).

Taken together, many of these aspects seem to indicate that CB are key for the correct functioning of the mechanisms upon which all socially constructed psychological competences are built. CB are salient and significant to human observers, so, as Rivière (2003) proposed, they might be one of the programs of attunement and harmonization with others that evolution has selected for the survival of the offspring in human beings, and the first two years of life are a critical period for their development.

The nature and function of CB in infancy have been extensively addressed in experimental settings for at least five decades (for a review see Meltzoff & Prinz, 2002; Jones, 2009; Oostenbroek et al., 2013; Bordoni, 2018; Davis et al., 2021). Studies of such nature usually wonder about the level of competence or dexterity of children’s CB and assess infants’ abilities in interaction settings with experimenters. On the other hand, observational studies of non-structured interactions between infants and their caregivers focus preferentially on how they put into practice those skills on a daily basis. As Masur (2006) posits, “the emphasis [observational studies] put on imitative use aims to record representative, rather than optimal, performance and on sampling typical, albeit less controlled, situations”. This kind of study simply observes unconstrained dyadic interactions that happen under no instruction for dyads to behave in a specific way. From an ecological perspective of behavior, observing how dyadic co-regulation occurs through CB in naturalistic studies is essential, since it is the only formula that allows us to contemplate CB’s natural occurrence and its consequences.

This review aims to systematically analyze how CB have been examined in observational studies of spontaneous mother-infant interactions in the first two years of life. Our intention is to trace the shared path of different forms of copying through infancy and to describe the diverse manners in which CB have been characterized as dyadic interactive patterns that facilitate processes of mother-infant co-regulation.

The questions that guide the present article are as follow:

1. How have CB been examined in mother-infant natural interaction studies?
2. How do CB contribute to mother-infant co-regulation processes?

2. Methods

2.1. Search strategy and eligibility criteria

The review protocol corresponding to the present article is available for reading at the Open Science Framework. Following the

Table 1
Characteristics of the included studies.

Study	Country	N (dyads)	Design		Observation moments	Mothers			Infants		Interactive situation ²	Time	Setting	Toys
			Cross-sect.	Long.		Status/health conditions	Ethnicity	SES	Dev. Status ^a	Sex (male, female)				
Waxler and Yarrow (1975)	USA	35	X		19 months	None	Black	Middle and lower-middle class	TD	18, 17	FIT + instructions to make the child imitate his/her mother	35 min	Lab	Yes
Pawlby (1977)	UK	8		X	4 – 10 months	None	Not informed	Middle class + 1 working class family	TD	5, 3	FIT	10 min	Lab	Yes
Field (1978)	USA	36	X		4 months	None	White	Middle-class	TD	18, 18	FFTF	3 min	Lab	No
Malatesta and Haviland (1982)	USA	60	X		2 groups: 3 & 6 months	None	Not informed	Social class skewed towards upper social status level	TD	Equal number of m & f	FIT + mother leaves and comes back to the room for 1 min	16 min	Lab	Yes
Field and Vega-Lahr (1984)	USA	24	X		3 months	None	Not informed	Middle socioeconomic status	Craniofacial anomalies (Cleft lip & palate) vs. TD	Not informed	FFTF	10 min	Lab	No
Field, Guy, and Umbel (1985)	USA	14	X		3½ months	None	Not informed	Middle-income mothers	TD	8, 6	FFTF + II	6 min	Lab	No
Malatesta, Grigoryev, Lamb, Albin, and Culver (1986)	USA	48		X	2½, 5 & 7½ months	None	Caucasian	Hollingshead Scale: preterm group, 57.5; full-term group, 56.7. Middle to upper social status level	Pre-term vs. full-term	34, 14	FFTF + mother leaves and comes back to the room for 1 min	8 min	Lab	No
Moran, Krupka, Tutton, and Symons (1987)	Canada	20	X		3 – 3 ½ months	None	Not informed	16 families were above the median Canadian SES ranking	TD	10, 10	FFTF	3 min	Lab	No
Uzgirir et al. (1989)	USA	80	X		4 groups: 2–3, 5–6, 8–9 & 10–12 months	None	Not informed	Lower-middle to upper-middle class population	TD	Equally divided in each group	FFTF + FIT	20 min	Lab	Yes
Harkins & Uzgirir (1991)	USA	57		X	8–9 & 11–12 months	None	Not informed	Lower-middle to upper-middle class	TD	31, 26	FFTF + FIT	20 min	Lab	Yes
Michel (1992)	USA	28		X	7, 9, 11 months	None	Not informed	Not informed	TD	14, 14	FIT	9 min	Lab	Yes
Ullstadius (1998)	Sweden	18	X		1–2 days (35–68 h)	None	Not informed	Not informed	TD	6, 12	FFTF + TP&MO ³ sequences	Not informed	Lab	No
Masur and Rodemaker (1999)	USA	20		X	10,13,17,21 months	None	19 European American, 1 African-American	Not informed	TD	10, 10	FIT + bath time	10–15 min	Home	Yes

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Table 1 (continued)

Study	Country	N (dyads)	Design		Observation moments	Mothers			Infants		Interactive situation ²	Time	Setting	Toys
			Cross-sect.	Long.		Status/health conditions	Ethnicity	SES	Dev. Status ³	Sex (male, female)				
Jonsson et al. (2001)	Sweden	39	X (cross-cultural)		Infants ranging from 2 to 12 months	None	22 Swedish; 17 Yugoslavian	Not informed (all families were similar in SES)	TD	22, 17	FFTF	15 min	Home	No
Kokkinaki (2003)	Greece	60		X (cross-cultural)	2–6 months	None	15 Greek, 15 Scottish	93.3% of the mothers had a paid employment	TD	16, 14	FFTF	8–10 min	Home	Not informed
Flynn, Masur, and Eichorst (2004)	USA	20		X	10,13,17 & 21 months	None	19 European American, 1 African-American	Not informed	TD	10, 10	FIT	10–15 min	Home	Yes
Field et al. (2005)	USA	32	X		3 months	Depressed (high and low anxiety & anger levels)	52% Hispanic, 28% White/Non-Hispanic and 20% African American	Lower-middle socioeconomic status (Hollingshead Index, $x^- = 3.2$)	TD	Not informed	FFTF + II	20 min	Lab	No
Valentino, Cicchetti, Toth, and Rogosch (2006)	USA	130	X		12 months	Abusing, neglecting & non-maltreating families	50% African-American, 30% European American and 20% Hispanic American	Lowest two social strata of Hollingshead Index	TD	57, 73	FIT + ABA Paradigm	25 min	Lab	No
Masur and Olson (2008)	USA	20		X	10,13,17,21 months	None	19 European American, 1 African-American	Same as in Masur and Rodemaker (1999)	TD	10, 10	FIT + bath time	10–15 min	Home	Yes
Field, Diego, Hernandez-Reif, and Ascencio (2009)	USA	63	X		3 months	Prenatal dysthymia/depression	53% Hispanic, 27% African-American and 20% non-Hispanic white Caucasian	Low to middle (Hollingshead Index, $x^- = 4.3$)	TD	31, 32	FFTF	10 min	Lab	No
Koester and Lahti-Harper (2010)	USA	63		X	9,12, 18 months	Deaf vs. hearing		Middle-class (Hollingshead Index)	Deaf vs. hearing	Not informed	FIT	10 min	Lab	Yes
Markodimitraki (2011)	Greece	1		X (case study)	1–10 months	None	Not informed	Not informed	TD	1 female	FFTF	21 min	Home	Not informed
Valentino, Cicchetti, Toth, and Rogosch (2011)	USA	78		X	12 & 24–30 months	Maltreating mothers	Ethnic minority: 66.7% of the abusing families, 82.1% neglecting families and	Time1: 78 infants from low-SES maltreating families and 52 infants from low-SES non-maltreating families.	TD	Time 1: 57 f, 73 m; Time 2: 78 infants	FIT	25 min	Lab	Yes

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Table 1 (continued)

Study	Country	N (dyads)	Design		Observation moments	Mothers			Infants		Interactive situation ²	Time	Setting	Toys
			Cross-sect.	Long.		Status/health conditions	Ethnicity	SES	Dev. Status ³	Sex (male, female)				
White, Flanagan, Martin, and Silvermann (2011)	USA	87	X		3½ months	BPD and/or major depression disorder	68.6% non-maltreating White, 17.2% Black, 11.49% Latina, 6.9% Asian, 6.9% Other.	Time2: comparable status Not informed	TD	44, 41	FFTF	5 min	Lab	No
Wörmann et al. (2012)	Germany	44		X (cross-cultural)	1½ & 2½ months	None	24 Cameroonian (Nso community), 20 German (Münster) Caucasian	German families: middle-class Not comparable to Nso sample	TD	Münster: 45% f, Nso: 54% f	FI	10 min	Home	Not informed
Kokkinaki & Vitalaki (2013a)	Greece	32		X	2–10 months	None	Caucasian	Middle-class families (according to Hollingshead Index)	TD	9, 7	FI	10 min	Home	Not informed
Kokkinaki & Vitalaki (2013b)	Greece	45		X	2–10 months	None	Caucasian	Middle-class	TD	14, 15	FI	10 min	Home	Not informed
Lavelli and Fogel (2013)	Italy	24		X	0–3 months	None	Caucasian	Nakao and Treas (1992) Socio-Economic Index of Occupations: occupational prestige scores of the parents ranged widely	TD	16, 8	FFTF	3 min	Home	Not informed
Wörmann et al. (2014)	Germany	44		X (cross-cultural)	1½, 2, 2½, 3 months	None	Same as in Wörmann et al. (2014)	Same as in Wörmann et al. (2012)	TD	Same as in Wörmann et al. (2012)	FI	10 min	Home	Not informed
Markova and Legerstee (2015)	Canada	44	X		12, 15 & 18 months	None	75% Caucasian, 19% Asian, and 6% African-American	Not informed	TD	25, 19	FIT + symbolic play with mother + structured imitation task	~23 min	Lab	Yes
Markodimitraki et al. (2016)	Greece	12		X	2–6 months	None	Caucasian	At least one adult in the family was employed	TD	6, 6	FI	5–7 min	Home	Not informed
Rayson, Bonaiuto, Ferrari, and Murray (2017)	UK	19		X	2 & 9 m months	None	95% identified as 'White (British/Irish/other White background)'	Not informed	TD	11, 8	FFTF + EEG task	3 min	Home	No

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Table 1 (continued)

Study	Country	N (dyads)	Design		Observation moments	Mothers			Infants		Interactive situation ²	Time	Setting	Toys
			Cross-sect.	Long.		Status/health conditions	Ethnicity	SES	Dev. Status ^a	Sex (male, female)				
Español et al. (2018)	Argentina	1		X (case study)	3, 4, 5, & 6 months	None	Not informed	Middle-class family	TD	1 male	FI	20 min	Home	No
Murray et al. (2018)	UK	50		X	0–2½ months	None	100% CLP white, 90% controls white	Not informed	Craniofacial anomalies (cleft lip)	11.11% male in CLP, 60% male controls	FFTF	3 min	Home	No
de Klerk, Lamy-Yang, and Southgate (2019)	UK	50	X		4 months	None	Not informed	Not informed	TD	1, 10	FFTF + EMG task	5 min	Lab	No
Markodimitraki and Kalpidou (2019)	Greece	27		X	1 & 10 months	None	Caucasian	Middle class families, majority of mothers were employed	TD	13, 14	FI	7 min	Home	Not informed

^a Developmental status: TD = typically developing. ² Interactive situation: FI = free interaction, FFTF = free face to face interaction, II = imitative interaction, FIT = free interaction with toys. ³TP = tongue protrusion, MO = mouth opening.

PRISMA guidelines (see the PRISMA Checklist in Appendix A), an electronic search was conducted on October 16th, 2020 (updated April 22nd, 2021) of the following databases: Psycinfo (including ERIC, Medline, Psycodoc and Psycarticles), Pubmed, Scopus and The Web of Science (including Scielo, current contents connect, KCI and Medline).

The following search terms were used: [title/abstract] ((mother-infant OR parent-infant OR infant-parent OR dyadic OR caregiver-child* OR mother-child* OR child-parent) AND (interact* OR play* OR synchrony OR respons* OR sensitivity) AND (imitat* OR mimic*)).

The search yielded 830 articles, 415 after duplicates were removed. Additional titles were retrieved by manually searching the reference lists of published studies and others that did not appear in the database search. Nine publications were then added to the ones from the database search.

The abstracts of the resulting 415 articles were screened by two reviewers for their potential in meeting the following inclusion criteria: (1) *Caregiver-infant interaction study* – a study in which interaction between an infant and his/her main caregiver(s) was observed and assessed; (2) Copy behaviors (including mimicry, imitation and other forms of labeling) are registered, described, mentioned or potentially taken into account within the studied variables of the dyadic interaction – but not if only vocal/verbal imitations were considered; (3) *Infants age is < 24 months* in, at least, one of the moments of measure; (4) *Publication type* – peer-reviewed publications, doctoral theses and/or relevant studies published in book chapters or congress publications; (5) *Language* – only studies published in English or Spanish were considered. Reviewer agreement was 97.11%. Disagreements were solved by consensus after full-text reading.

Of the total, 248 articles were excluded for not meeting the preliminary criteria. Then, 167 articles were full-text reviewed by the main researcher (see the Eligibility Criteria in Appendix B). Of those, 48 records were finally excluded for focusing only in vocal or verbal imitative behaviors, 20 did not fulfill the age criteria, 15 were not accessible in full text, 41 did not assess imitative exchanges in natural interactions or these exchanges happened exclusively under instruction to imitate or make the children imitate, 6 did not take mothers as the main caregivers under study, and 1 was a narrative review. The final sample of studies comprised a total of 36 documents (see Fig. 1).

Twenty of the 36 studies (55.56%) were carried out in the USA or Canada, 15 (41.67%) in European countries, and only one (2.78%) in Latin-America. The years of publication ranged between 1975 and 2019 and the majority of the studies were published as

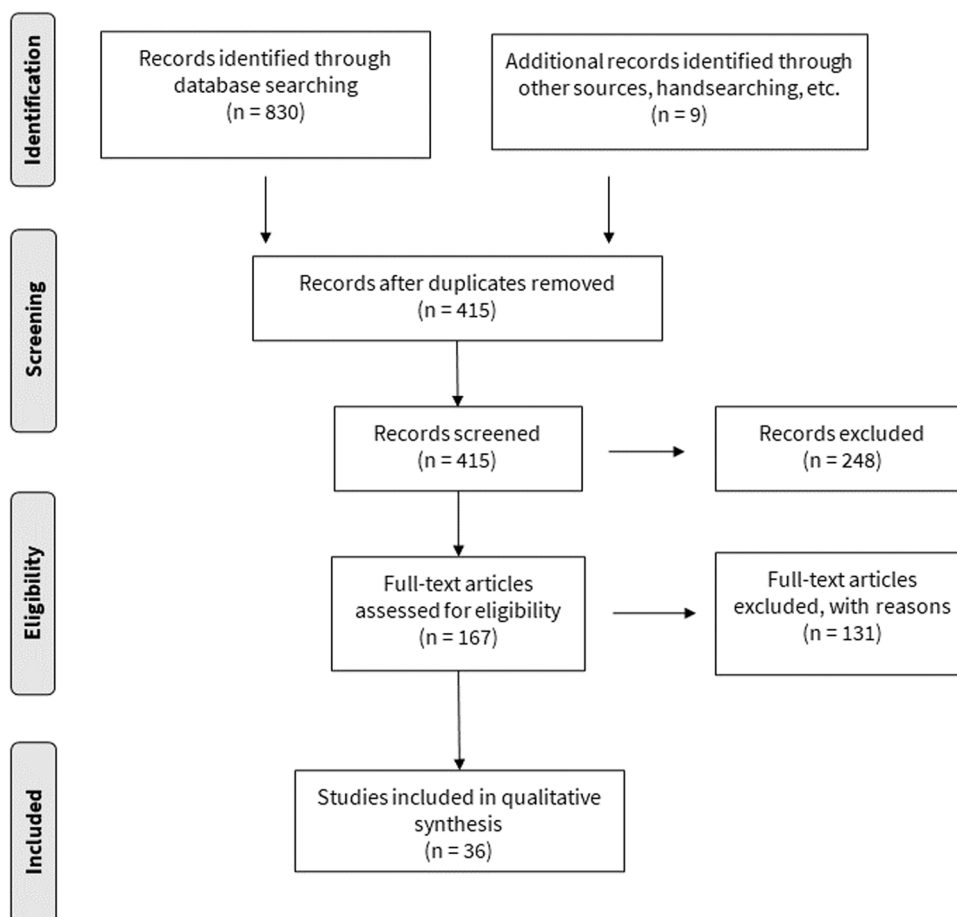


Fig. 1. PRISMA flowchart.

peer-reviewed articles ($n = 32$), but there were also 2 congress publications (Markodimitraki, 2011; Markodimitraki et al., 2016;) and 2 book chapters that described the results of empirical studies (Pawlby, 1977; Uzgiris et al., 1989). See Table 1 for further details on the year and country of origin of the studies.

Due to the complexity and broad range of studies retrieved, a formal assessment of the risk of bias was not conducted. The different nature of the studies and research designs (either cross-sectional or longitudinal) made it not possible to use a single tool for addressing it.

2.2. Data extraction

The following information was extracted from the final 36 studies: year of publication, country of origin of the study, sample characteristics (N size, ethnicity, socio-economic status, infant's developmental status), study design, assessment moments (infants' ages in months), interaction context (setting, display, duration, use of objects, instructions given), main research constructs, CB labeling and definition, aspects of CB assessed (agency focus, modality, frequency, nature, effects or consequences) and findings on interactive patterns reported.

The information extracted from the selected 36 articles is presented below, articulated around the main research questions addressed.

3. Results

3.1. Overview of the study of CB in mother-infant natural interactions

All the included studies observed situations of interaction between infants aged 0–24 months and their mothers and registered at least one episode of non-structured CB. Some studies recorded these behaviors as an element or a pattern within the overall observation of the interaction ($n = 12$), while others focused solely on CB as their main interest of study ($n = 24$).

3.1.1. Composition and characteristics of the dyads

The number of dyads examined in the selected studies (see Table 1) varied from 1 (Markodimitraki, 2011; Español et al., 2018) to 130 (Valentino et al., 2006), with a mean of approximately 40 dyads ($\bar{X} = 39,8$; $SD = 26,66$). All 36 studies took mother-infant dyads as their focus of research, but 4 of them also addressed and/or compared dyadic interactive patterns of infants with other caregiving figures such as fathers (Field, 1978), grandmothers (Kokkinaki & Vitalaki, 2013a, 2013b) or siblings (Markodimitraki, 2011).

In 3 of the 36 studies, all, or part of the sample of mothers presented mental health conditions or psychiatric disorders that were of particular interest for establishing comparisons with healthy controls' patterns of interaction. These disorders were major depressive disorders (Field et al., 2005), pre-natal dysthymia (Field et al., 2009), and/or borderline personality disorder (White et al., 2001). In one additional study, half of the mothers in the sample were deaf (Koester & Lahti-Harper, 2010). The other 32 studies did not report any characteristics concerning mothers' mental or physical health conditions. However, there were 2 studies that established comparisons between the interactive patterns of maltreating, abusive and non-maltreating families (Valentino et al., 2006, 2011) and 4 cross-cultural studies that sought to make interaction comparisons based on sociocultural differences (Jonsson, 2001; Kokkinaki, 2003; Wörmann et al., 2012, 2014). Table 1 contains further details on mothers' demographic data.

The infant samples in 32 of the 36 studies were fully composed of healthy, typically developing (TD) children. Therefore, only 4 studies utilized a sample of non-typically developing infants: both Field and Vega-Lahr (1984) and Murray et al. (2018) used a sample of infants with craniofacial anomalies (cleft lip and palate); Malatesta et al. (1986) compared the interactive dyadic behaviors of pre-term vs. non-preterm infants, and Koester and Lahti-Harper (2010) included both hearing and deaf infants in their sample. The sex distribution of the infants was generally balanced among the studies (see Table 1).

3.1.2. Methodology: design, setting and procedures

The majority of the research was based on group comparisons, but there were two case studies (Markodimitraki, 2011; Español et al., 2018). Fifteen of the total studies had a cross-sectional design, one of them with a cross-cultural aim (Jonsson et al., 2001). The other 21 were longitudinal studies. Among those, three had also a cross-cultural perspective (Kokkinaki, 2003; Wörmann et al., 2012, 2014) (see Table 1).

The studies were carried out either in laboratory settings ($n = 20$) or at the homes of the participants ($n = 16$). The amount of time of interaction recorded ranged from 3 min to 35, but the most frequent duration of the interaction was between 8 and 10 min.

Twelve studies involved or allowed the manipulation of toys, 15 did not permit the use of objects during the interaction recording and 9 did not explicitly inform about this. Consequently, the interactive situations raised by the researchers are classified in Table 1 as follows: free interactions (FI) ($n = 7$), in which mothers and infants are allowed to interact freely without an specific configuration of the scenario; free face to face interactions (FFTF) ($n = 14$), where the members of the dyad interact looking at each other with no object manipulation; imitative interactions (II) ($n = 2$), in which mothers are asked to interact imitatively towards their children, and free interactions with toys (FIT) ($n = 13$), in which free play with age-appropriate toys is allowed to the dyad.

Regarding the observation setting, most of the studies were displayed with the two partners facing each other, the infant either sitting in a child's chair, on his mother's lap or on a tabletop. When toys were offered, the interaction used to take place at a table, and on the floor in the case of older children. However, there were exceptions to this, especially among studies carried out at the homes of the families – thus, two studies assessed interactions during bath time (Masur & Olson, 2008; Masur & Rodemaker, 1999).

Table 2

Research constructs and CB characterization reported by each of the included studies.

Study	Research construct	CB labeling	Definition of CB	CB agent	Modality of CB
Waxler and Yarrow (1975)	Imitation reinforcement, characteristics of model and modeling in mother-infant interactions.	Imitative acts	Responses that appeared in the child's behavior after similar acts had been performed by the mother but had not been performed earlier by the child.	Children	M-O
Pawlby (1977)	Imitative sequences in mother-infant communicative framework	Imitative sequences	Form of communication sequence in which one of the two partners (mother or infant) reproduces the same act as that previously emitted by the other partner, provided that the two acts can be observed as having a direct relationship with one another	Both	F, M-B, M-O, V/V
Field (1978)	Interactive patterns of primary and secondary caretaker parents	Imitative behaviors (smiles & imitative grimaces)	Not defined in text	Mothers	F, V/V
Malatesta and Haviland (1982)	Infant expressiveness socialization by the mother.	Matching of facial expressions	Contingent matching responses to facial expressions.	Mothers	F
Field and Vega-Lahr (1984)	Face-to-face interactive patterns of cranio-facial anomaly infants and their mothers.	Imitative behaviors	Not sufficiently described in text	Mothers	Not specified
Field et al. (1985)	Smiles and vocalizations subsequent to maternal imitation as a function of her imitative or non-imitative behaviors.	Imitative behaviors (smiles & vocalizations)	Smiles and vocalizations where the pitch, form, and intonation of sounds match closely the infant's immediately preceding behavior (2-sec time frame).	Mothers	S, V/V
Malatesta et al. (1986)	Interactive patterns of pre-term vs. full-term infants: imitative/matching and dissimilar responses from mothers	Contingent responses: matching vs nonmatching	Change of maternal expression within a second following an infant expression change.	Mothers	F
Moran et al. (1987)	Occurrence and characteristics of imitation in mother-infant interactions	Imitation/Matching	The onset of an act within a particular time span following an onset in the same category by the partner.	Both	F + V/V
Uğçir et al. (1989)	Matching activity in mother-infant dyads in face-to-face and toy play situations.	Matching episodes	Instances where the mother replicates an act of the infant as well as instances where the infant replicates an act of the mother. Defined as extending from the beginning of the act that was then replicated by the partner to the last production of this act by one of the partners.	Both	F, M-O, M-B, V/V
Harkins & Uğçir (1991)	Hand-use matching between mother and infant during object play	Hand-use matching episodes	Instances in which and act by a partner (initiator) was reproduced by the other partner (imitator), within 2 s of the initial act.	Both	M-O
Michel (1992)	Hand-use matching between mother and infant during object play	Hand-use matching episodes	Matches of hand-use = infant's use, within the 10-s scoring interval of the same hand used by the mother.	Children	M-O
Ullstadius (1998)	Neonatal imitation of TP and MO	Imitation of TP&MO	Not defined in text	Children	F
Masur and Rodemaker (1999)	Developmental course of imitative exchanges between mothers and infants	Imitations	Matching of discrete behaviors that complied 3 conditions: attention from imitator, contingency in imitator's behavior, and sufficient quality of the copy.	Both	M-B, M-O, V/V
Jonsson et al. (2001)	Affect attunement in relation to imitation during the first year of life in two cultural contexts.	Imitation vs. Affect attunement episodes	Imitation: mimicking of facial expressions, movements and vocalizations using the same	Mothers	F, M-B, V/V

(continued on next page)

Table 2 (continued)

Study	Research construct	CB labeling	Definition of CB	CB agent	Modality of CB
Kokkinaki (2003)	Emotional states before, during and after imitations in dyadic interactions with parents in two cultural contexts	Imitative episodes	modality of behavior with no clear affective emphasis. Period from the moment that the model's expressive act starts until the completion of the imitator's last imitative activity. When one individual's vocal, kinetic, facial expression, or any combination of these is 'recreated or reproduced' by his or her partner within a 10-second interval.	Both	F, M-B, V/V
Flynn et al. (2004)	Predictors of infants' and mothers' imitations (dispositional factors vs interpersonal factors)	Imitations	Discrete non-facial imitative behaviors, following same criteria as in Masur and Rodemaker (1999)	Both	M-B, M-O, V/V
Field et al. (2005)	Interactive patterns of depressed mothers with high and low anxiety or anger and their infants in natural and imitative situations	Imitative behaviors	Not sufficiently described in text	Both	Not specified
Valentino et al. (2006)	Influence of maltreatment subtype differences on children's play behaviors.	Imitation	Child imitates specific behavior/motion/verbalization first done by mother (only immediate imitation, occurring within five minutes of maternal behavior, is coded as imitation)	Children	M-B, M-O, V/V
Masur and Olson (2008)	Responses of mothers and babies to each other's imitations. Relation to acquisition of vocabulary and recognition of imitation	Imitations	Same as in Masur and Rodemaker (1999)	Both	M-B, M-O, V/V
Field et al. (2009)	Interactive patterns of mothers with prenatal depression vs dysthymia and their infants	Imitation	Not sufficiently described in text	Mothers	Not specified
Koester and Lahti-Harper (2010)	Intuitive parenting behaviors in deaf vs. hearing mothers	Imitation	An exchange between caregiver and infant in which one partner reproduces the act of the other (based in Pawlby, 1977).	Mothers	F, M-B; M-O, V/V
Markodimitraki (2011)	Frequency, direction, and structure in mother-infant and sibling-infant dyadic imitative interactions	Imitative sequences	Exchange in which one partner did something that had not been done by either partner in the immediately preceding 10-s and in which the other partner reproduced this activity within a 10-s interval and with no other intervening activities.	Both	F, M-B, V/V
Valentino et al. (2011)	Influence of maltreatment subtype differences on children's play behaviors.	Imitations	Same as in Valentino et al. (2006).	Children	M-B, M-O, V/V
White et al. (2011)	Effects of MDD disorder, BPD, and their co-morbidity on mother infant interactions compared to healthy controls.	Imitations	Not sufficiently described in text	Mothers	Not specified
Wörmann et al. (2012)	Cross-cultural differences in social smiling development	Social smiling	Maternal imitation: onset and offset during mutual gazing when mothers responded within 3 s to the intensification (onset) or reduction (offset) of their infant's smile by intensifying or reducing their own smile. Infant: same as maternal, but within 6 s interval.	Both	S

(continued on next page)

Table 2 (continued)

Study	Research construct	CB labeling	Definition of CB	CB agent	Modality of CB
Lavelli and Fogel (2013)	Developmental path of interactive patterns of mother-infant interactions	Mirroring	Mother is mirroring an infant's action either by imitating it quite literally or with particular emphasis or by reproducing the affective quality (i.e., rhythm, affective contour, intensity) of the infant's action through modalities of communication that differ from those used by the infant.	Mothers	F, B-M, V/V
Markova and Legerstee (2015)	Role of maternal behaviors on child's pretense and imitation of pretend play.	Imitation	A pretense/imitative act started when an individual picked up a toy and reproduced a symbolic action immediately after it was demonstrated by the partner, or the person switched from exploratory or functional play with a toy to an act of pretense/imitation.	Children	M-O
Markodimitraki et al. (2016)	Imitation in spontaneous mother-non twin infant and mother/twin-twin infant dyadic and mother-twin-twin triangular interaction	Imitative sequences	Same as in Markodimitraki (2011) .	Both	F, M-B, V/V
Rayson et al. (2017)	Maternal mirroring as a predictor of infants' neural mapping mechanisms.	Mirroring	Maternal response that is an exact match of the infant's behavior, or a match of the main features with some minor modification	Mothers	F, M-B, V/V
Español et al., 2018	Reciprocity patterns in early social play: affect attunement vs. imitation	Imitation vs. Affect attunement episodes	Moments of the interaction in which coincidence or similarity is established between the behaviors of the participants, which allow establishing a special degree of mutuality.	Mothers	F, M-B, V/V
Murray et al. (2018)	Infant expressiveness and parental responsiveness in infants with cleft lip	Mirroring	Responses of the same valence and intensity as the infant's behavior that are either exact matches, or that match the principal features with some minor modification.	Mothers	F, V/V
de Klerk et al. (2019)	Mimicry's relation to perceptual-motor couplings' opportunities	Mimicry	Mimicry: presence of greater activation over corresponding muscles than over non-corresponding muscles during the observation of facial actions.	Both	F
Markodimitraki and Kalpidou (2019)	Developmental course of imitative exchanges in mother-infant interactions	Imitative episodes	Social act during which one partner expresses an act not expressed by either partner in the immediately preceding 10 s, and in which the other partner reproduced within an interval of less or equal to 10 s	Both	F, M-B, M-O, V/V
Kokkinaki & Vitalaki (2013a)	Imitative interaction patterns in grandmother-infant vs mother-infant interactions	Imitative episodes	Same as in Markodimitraki (2011) .	Both	F, M-B, V/V
Kokkinaki & Vitalaki (2013b)	Imitative interaction patterns in grandmother-infant vs mother-infant interactions	Imitative episodes	Same as in Markodimitraki (2011) .	Both	Same as in Kokkinaki et al., 2013a
Wörmann et al. (2014)	Cross-cultural differences in social smiling development	Social smiling	Same as in Wörmann et al. (2012)	Both	S

All mothers were prompted, at least on one occasion, to interact with their children with no further indications other than "play with your child as you would normally do" (or equivalent) or, at most, were given instructions to use one toy or another in different moments. The nature of the CB registered was, therefore, mostly spontaneous, except in the cases in which the study design required

mothers to, apart from participating in a natural interaction observation, behave in a certain way.

Several studies solicited mothers to, additionally to the free interaction, act “imitatively” towards their children (Field et al., 1985, 2005) or seek to provoke CB in their infants (Ullstadius, 1998; Waxler & Yarrow, 1975). There were also two studies in which mothers were asked not to initiate interactions but respond to their child’s initiations for a brief period of the total interaction time (“ABA paradigm”; Valentino et al., 2006, 2011). In such cases, the imitations registered from both mothers and infants cannot be considered as completely unconstrained, since the behavior of at least one of the partners was modified by an external influence.

The moments of observation of the mother-infant interactions varied from newborns that were less than 1 month of age (Lavelli & Fogel, 2013; Markodimitraki & Kalpidou, 2019; Markodimitraki, 2011; Murray et al., 2018; Ullstadius, 1998; Wörmann et al., 2012, 2014) to infants ranging between 24 and 30 months (Valentino et al., 2011). This spectrum of measurement moments varied depending on whether the studies had a longitudinal or a cross-sectional design (See Table 1 for further information). About eighty percent of the studies ($n = 29$; 80.56%) observed the dyads between their 1st and 12th month – meaning, during their first year of the infants’ life –, while only 7 studies (19.44%) aimed to describe interactive patterns occurring beyond the beginning of the second year.

Relative to the focus on the agency of CB, 10 studies addressed the CB produced by the adult figures, while 5 leaned towards the exclusive analysis of CB produced by the infants. The other 17 studies observed and described the actions of both interacting partners of the dyad.

The modalities of the CB registered belonged to one or more than one of the following categories (see Table 1): Motoric-Body movements (M-B) ($n = 19$); Motoric-Manipulation of Objects (M-O) ($n = 13$); Facial gestures (F) ($n = 20$); Vocal / verbal (V/V) (vocalizations, speech and non-speech sounds) ($n = 23$) and Social smiling (S) ($n = 2$). There were four studies that did not indicate if the CB reported were of any of these kinds.

3.2. Many terms for a complex construct: CB in the reviewed studies

As was expected, several different terms were used in the reviewed literature to identify CB. The use of a specific term, label or conceptualization of CB varied depending on its definition and operationalization, the precise features of the copy that were analyzed, the agent of the copy primarily considered – mother, child or both interactants –, whether the use of toys was allowed during the observation, and the research group or methodological tradition to which the researchers ascribed, among other aspects.

Table 2 shows the labeling, characteristics and descriptions of the different CB depicted in each of the 36 studies reviewed.

The heterogeneity in the descriptions provided, as well as the methodological and technological differences employed in each study, prevent a precise classification of the CB addressed by each group of authors. However, it seems reasonable to think that, in many cases, the behaviors assessed were closer to mimicry than to intentional imitation, for example; and that perhaps some even refer to other kinds of CB. There simply may not have been precise clarifications of the copying phenomenon under study in each paper reviewed.

As an illustration, in some studies, the kinds of copied responses were mainly facial expressions, smiles and vocal/verbal productions, all of which are likely to occur involuntarily, more as a result of automatic interpersonal reciprocity or mimicry (de Klerk et al., 2019; Moran et al., 1987; Rayson et al., 2017; Wörmann et al., 2012, 2014). On the contrary, other studies clearly described complex imitation, mediated by a means-ends logic and deliberation that was usually driven by the manipulation of objects (Masur & Rodemaker, 1999; Waxler & Yarrow, 1975; Masur & Olson, 2008; Markova & Legerstee, 2015). Behaviors such as the correct functional use of a nesting toy or a shape-sorter require some extent of understanding, in addition to the characteristics and physical restrictions of the object, the goals and purposes of the model that has manipulated it in the first place. However, it is possible that even some of these copies responded to automatic interpersonal matching processes (e.g. in hand-use matching studies).

Due to the longitudinal and comprehensive aim on describing the evolutionary trajectory of all kinds of CB, many of the reviewed studies probably include, with no differentiation, different types of CB in their analysis. For example, the works of Pawlby (1977) or Markodimitraki and colleagues (2011, 2016, 2019) collected samples of a variety of CB in infants from their first to their 10th month of life, tracing a trajectory that, necessarily, transited from rapid, simple mimicking towards increasingly complex and intentional imitation behaviors, and possibly incorporated other forms of copying as well.

The idea that is intended to underline with these distinctions is that the variability in defining and interpreting CB could lead to differences in the interpretation of results, but this does not undermine the potential of any type of CB when it comes to enriching or establishing patterns of mutual regulation in mother-infant interactions.

3.3. Findings on co-regulation processes through CB

There is an overall transactional rationale in the relationships that are mutually created upon CB in the mother-infant dyads: both interactants build co-regulatory sequences by continuously modifying the behaviors and emotional states of the other based on their ongoing and anticipated actions (Evans & Porter, 2009).

Several findings in the 36 studies that compose this review support the view of CB as co-regulatory facilitators within mother-infant dyadic interactions, even when the main purpose of those studies was not to picture them as that (for an overview of the research constructs addressed by each study, see Table 2).

We propose that CB facilitate interactions and contribute to co-regulation processes, exerting an impact on the dyad’s emotion and affect, communicative exchanges and actions on the physical world. Due to this, CB can also be depicted as indicators of maternal sensitivity towards her infant and a sign of the infant’s attentiveness to the adult. Results in this regard are presented below.

3.3.1. Co-regulation of emotions through CB

One possible effect that CBs have on the dyad is contributing to the affective co-regulation of both partners. In particular, studies that explore mimicry affirm that it is a powerful interpersonal transmitter of emotional states through what is called *emotional contagion* (Hatfield et al., 1993) – a phenomenon that happens bidirectionally in the dyad. As some of the reviewed studies show, maternal mimicking provides an opportunity for the differential reinforcement by the mother of certain forms of infant facial expressions—particularly the most positive ones (Malatesta & Haviland, 1982; Moran et al., 1987; Rayson et al., 2017). Such maternal expressions of congruence also relate to affective sharing, regulate the intensity of interaction and help to maintain a comfortable level of involvement for the two participants, not only through mimicry but also in overt imitation exchanges (Uzgiris et al., 1989). These processes are part of the affective “feedback frame” that mothers create for children in their interactions, exerting a clear influence on their emotional states.

Meanwhile, infants’ capacity to display a certain variety of emotional expressions conditions the number of opportunities mothers have to differentially reinforce those of their interest. For example, infants’ social smiles in highly interactive contexts are perceived as important moments, full of positive emotional meaning for mothers (Stern, 1974), but are not so frequently displayed and reinforced in some cultures (Wörmann et al., 2012, 2014).

Thus, a supra-individual affective attunement mechanism that harmonizes the emotions of each member and makes them more homogeneous can be identified in CB, either through *emotional matching* (coincidence of emotions) or by *emotional attunement* (coincidence of emotional valence shifts) processes (Kokkinaki, 2003; Markodimitraki & Kalpidou, 2019). These phenomena make it possible to differentiate between the affective states each partner experiences while, at the same time, making a global assessment of the emotional climate shared by the dyad as a whole.

3.3.2. Co-regulation of communication through CB

Both members of the dyad initiate and maintain communicative exchanges supported on CB. Copying seems to strengthen the “dialogue” between children and their mothers, contributing to infant’s vocabulary growth and influencing the frequency of their mothers’ praise and verbal responses (Masur & Olson, 2008; Masur & Rodemaker, 1999). Even children who come from abusing families rely on imitation of their maltreating mothers in attempts to elicit positive responses from them (Valentino et al., 2006, 2011).

Caregivers are the ones that most frequently imitate the behaviors of the infant, which may be interpreted as a sign of adult scaffolding effort on maintenance and enrichment of the dyadic communication (Kokkinaki & Vitalaki, 2013a, 2013b; Kokkinaki, 2003; Markodimitraki, 2011; Markodimitraki et al., 2016 and Markodimitraki & Kalpidou, 2019). Interestingly, in dyads of deaf mothers and their infants, gestural imitation was found to be extendedly used by these mothers (Koester & Lahti-Harper, 2010). This can be seen as a form of reinforcement of signed language development as it equally happens in oral communication.

Despite CB often occurring simultaneously (e.g., both partners show the same facial expression at the same time), the fact that the members of the dyad tend to inhibit their vocalizations while their other partner vocalizes is a sign of delicate co-regulation through an effort to avoid communicative interferences between interactants (Moran et al., 1987). Such turn-taking structure often characterizes CB-based exchanges and has consistently been described throughout several of the reviewed studies (Kokkinaki & Vitalaki, 2013a, 2013b; Kokkinaki, 2003; Markodimitraki, 2011; Markodimitraki et al., 2016; Pawlby, 1977). Co-regulation patterns become evident through all these mutual communicative influences.

3.3.3. Co-regulation of actions through CB

Many manipulative behaviors and forms of play are prompted through CB-based exchanges. Adults often modulate their actions in ways that facilitate action processing for their infants through what has been described as *motionese* (Brand et al., 2002). Observing each other’s actions, mothers and children often modify their behaviors to better fit those emitted by their partner.

Masur and Olson (2008) establish that, as early as 10 months, infants show increasing awareness of being copied and therefore display consistent return imitations to their mothers’ action matching, often through the use of objects. Such observation is supported by the findings of Saby et al. (2012), which indicate that the effects of being imitated are also detectable at the neurophysiological level, in 14-month-old infants, that show preference for adults who copy their actions over those who do not.

Moreover, as Markova and Legerstee (2015) claim, maternal scaffolding through pretense and her own imitation of pretense acts serve as a contextual support to elicit and reinforce the children’s own symbolic play. Another example of how certain behaviors are learned—at least partially—through CB is maternal impact on offspring’s handedness through hand-matching mechanisms (Harkins & Uzgiris, 1991; Michel, 1992). Again, co-regulation emerges from the back and forth dynamic of each partner’s CB, which are facilitated by specific tuning mechanisms that emerge in the dyad and shape mothers and infants’ subsequent activities and influences on the surrounding environment.

3.3.4. Quality of the dyadic interaction through CB

Mothers’ ability to correctly perceive and interpret their infants’ cues and to respond to them in an appropriate and well-paced manner includes her aptitude to choose valuable opportunities to copy her infant’s behaviors, as a way of showing responsiveness to their child’s requests.

Several of the included studies support the idea that maternal reinforcement through CB may be an indicator or an element that enhances and supports her degree of awareness to the child’s states, and, ultimately, her involvement with him/her (Lavelli & Fogel, 2013; Waxler & Yarrow, 1975). Some occasions that demonstrate this sensitivity are the times when mothers recognize and seize the opportunities that make infant’s copying more likely (Flynn et al., 2004).

It is also possible to interpret CB as indicators of the infants’ degree of attentiveness to the caregiver since, as has been said, in

addition to spontaneously copying their mothers, they are able to identify when they are being imitated and demonstrate it through counter-imitations (Masur & Olson, 2008).

Nevertheless, when the dyadic scenario is influenced by some mental health condition affecting the adult figure (e. g. anxiety, depression, bipolar disorders), there is an increased probability of maladjustment in the dyad's mutual regulatory influence (Field et al., 2005, 2009; White et al., 2011). Probably these mothers are less sensitive or unable to read their children's needs or intentions, and therefore less capable to take advantage of the opportunities to imitate them as a form of creating positive interactions.

Atypical developmental trajectories of infants can also affect the overall degree and characteristics of the dyadic co-regulation through CB. Some examples can be found in interactions between mothers and their pre-term infants or in infants with craniofacial anomalies (Field & Vega-Lahr, 1984; Malatesta et al., 1986; Murray et al., 2018). In these dyads, infants' abilities to send social signals and to communicate successfully with their caregivers through CB may be impaired compared to their typically-developing peers.

4. Discussion

Studying spontaneous CB in their naturally occurring context is a window into reality that embraces the complexity of interaction in a way that experimental designs do not permit. Therefore, what was addressed in this review constitutes a research field that offers an ideal opportunity to observe, ecologically, the co-regulation experiences mothers and infants undergo when exchanging CB.

Despite – or perhaps thanks to – the heterogeneity in the objectives pursued and the methodologies used by the studies included, there are certain ideas that can be noted from the analyses carried out in this review.

First, there were a clear majority of studies that observed dyadic interactions exclusively in the first year, and more specifically, that focused on the infants' first weeks and months of life. This probably responds to the scientific tradition established upon the seminal studies of Maratos (1973), Meltzoff and Moore (1977) and Kugiumutzakis (1998), all of whom tried to unravel the wonders of the *neonatal imitation* phenomenon – a field of discussion that continues to our days (Slaughter, 2021). Another reason to explain why the body of research is greater in the scope of the first months is, undoubtedly, because of the interest of exploring CB in the origin of affective and attachment ties, as a matter of, perhaps, cause and effect. However, after the first 12 months the mother-infant dyad continues to be a complex unit of interaction within which children's social competences become more sophisticated. After the 12th month, spontaneous and naturalistic, motoric, gestural and object-related copying behaviors happening within the dyad go more often unnoticed and seem to stop attracting research interest from that moment on. Research at these ages has tended to become increasingly experimental. Of course, there is a higher need for control over the interactive variables and therefore more research is done with experimenters instead of mothers, but the value of observing all kinds of CB in their context of natural occurrence beyond the first year should not be lost from sight.

Second, there is remarkable variability in the terminology that has been employed when measuring CB in natural interaction settings. It seems undeniable that every form of copying belongs to a constellation of tools that sustain and enrich interpersonal reciprocity and contribute to the feeling of dyadic mutuality between mothers and infants. However, as some other authors have proposed before (Noble & Todd, 2002), there appears to be a significant lack of consensus on how to operationalize what, in general, has been labeled as “imitation”. This makes it difficult to establish comparisons between specific findings regarding, for example, the evolutionary trajectory that CB present. It also explains, at least partially, the “noise” that, for decades, has characterized CB research. Observational studies up to date have generally addressed CB without considering, for example, the degree of voluntariness or automaticity of the described copies. Accordingly, some authors have raised the possibility that mimicry may serve more to strictly social communicative and bonding functions, while intentional imitation may be more linked to apprenticeship functions involving tool use and instrumental learning (Rogers, 2006). Perhaps it would be worth increasing our efforts as scientific community to refine our definitions of CB and, thus, facilitate the comparison between studies and the reaching of significant conclusions about the role these behaviors play in early development. In this sense, it is important to pay attention to the criteria used to define what is coded as a CB and to bear in mind its specific function in the dyadic interaction.

Third, regarding the co-regulation that occurs through the exchange of CB, the results derived from our analysis allow us to verify the existence of co-regulatory effects in both directions and at several different levels of analyses between the members of the dyad. Although adult figures have greater capacity to set the pattern of interaction and their agency over the infant's behaviors is greater than vice versa (Calkins, 2011; Pawlby, 1977), CB are also powerful tools that children use to provoke specific responses in their mothers. Co-regulation through CB occurs in terms of affective attunement, maintenance and prompting of social and communicative interaction, as a trigger for actions on the physical world and, ultimately, represents a sign of maternal sensitivity and quality of the interaction.

In conclusion, the first forms of CB clearly start to root as patterns of interaction at the very beginning of life, and they contribute in all their formats to mother-infant interactive co-regulation of both their affects and behaviors. However, there is still a long way to go when it comes to specifying which copying phenomena are those that contribute to a greater or lesser extent to such co-regulation.

4.1. Limitations

This review lacks, first, a broader approach that would permit the inclusion of studies that exclusively assessed vocal and verbal CB. This type of research was excluded from our work because it represents a body of literature that deserves being addressed in an encapsulated way. Including such research in this analysis would have been a task beyond our pretensions.

Also, a more varied range of publication types could have been reviewed. Although doctoral theses were originally included, none of the selected could be finally accessed. Gray literature or dissertations were not considered either. However, chapters of books and

publications derived from congresses were incorporated.

Another limitation worth noting is the language of publication: only works written in English or Spanish were taken into account. As most of the studies originated in North America and Europe, it is likely that our database search led to a bias in both the methodological approaches and the results obtained. Nonetheless, it should be noted that there were several works that adopted a cross-cultural approach.

Finally, it is important to reflect on two additional aspects: one, that the caregiving figures that have been taken as a reference in this review were only mothers. Mothers, as has been said, are usually the ones in charge of nurturing infants, especially in western cultures. Still, it is important to broaden this scope, since today's society increasingly incorporates other figures of attachment to the newborns' life, and the norm that it is the mother who spends more time with the child is no longer valid for all children the same. As Field (1978) argued years ago, the most relevant aspect for parents to recognize and respond contingently to their children's CB is the amount of time they daily invest in interacting with them, regardless of their sex. Nevertheless, and although the mother-centered paradigm is beginning to evolve, this does not undermine the intrinsic interest of studying mother-infant dyads. The other has to do with the methodology and criteria for selecting the studies. Some of the papers reviewed were not fully unconstrained or unscripted. We have pointed it out above and justify our decision of including a broader range of studies as long as they incorporated, at least, a situation of free interaction.

4.2. Future research directions

Many of the studies included in this review contemplated the mutual influence, both emotional and behavioral, derived from CB between mothers and infants, but few raised this analysis to a level where the recorded behaviors allowed to directly measure how CB contribute to the quality of the interaction or other global aspects of the dyad (e. g. interactive synchrony, mutuality or engagement). As others also suggest (Legerstee & Varghese, 2001), it would be valuable to deepen into the study of CB as measures of maternal sensitivity to her infants' needs, or alternatively as measures of the infants' attentiveness to his/her mother. Especially when our interest is to talk about co-regulation, it seems essential to keep a global perspective on the dyad and not on its members separately.

Another aspect that this review has made clear is that it seems important to delve into the developmental outcomes that relate to early CB happening in natural contexts. Imitation has been linked to numerous social, communicative, linguistic and cognitive skills, but in most cases, this has been done on the basis of strictly experimental research. We believe that it is important to examine these findings in ecological situations to test their generalizability. An area of interest about which there is still little knowledge is the potential influence of CB happening within mother-infant interaction on motor infants' development (Rocha et al., 2020). By doing so, perhaps, we will add new gradations to our knowledge and help to understand to what extent CB contribute to the quality of dyadic interaction, whereas describing how what happens within it has a subsequent impact on the child's development.

It would also be important to collect a greater amount of demographic and contextual information relative to the families and to incorporate them into the analyses, hence capturing more accurate pictures of the reality in which each mother-infant system is inserted. Thus, CB might present subtle differences among ethnicities and parenting traditions that are yet to be explored. At the same time, there is still a need to attend to the health status of caregivers, since the influence they exert on their infants through CB can be negatively affected by certain risk factors not yet evaluated in literature. For example, the degree of endured parental stress, the influence of maternal interactions with her other children or the degree of support mothers receive in parenting.

Lastly, most of the literature reviewed did not incorporate standardized measures of global development to establish a baseline among participant infants. This is something that could provide important clues regarding the atypical developmental trajectories that infants might present. Considering developmental disorders in unstructured interaction studies that assess CB remains a pending task, and takes on special relevance in those conditions where social cognition is compromised (Rogers et al., 2003; Schwichtenberg et al., 2019; Weisman et al., 2015). Delving into this field to open new windows for parent-mediated interventions in natural contexts and helping to better adjust dyadic co-regulation processes in these families should be a primary objective for developmental scientists.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.infbeh.2022.101749](https://doi.org/10.1016/j.infbeh.2022.101749).

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