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The Temporal Dimension in Maternal Sensitivity Predicting Organized Attachment in Children

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Abstract: *This study analyzed Maternal Sensitivity in the interaction of mother-infant dyads to distinguish different dynamics associated with their attachment group membership – Insecure-Avoidant (A), Secure (B), or Insecure-Resistant (C), with no Disorganized traits – that they developed at 15 months. Participants were 26 eight-month old infants interacting with their mothers in a free-play setting. The analyses used sequential streams of infant actions and maternal responses, and state-space grids to study the temporal organization of the sequences. We examined appropriateness and promptness of the maternal response to infant behavior and a dynamic analysis of the interactive process. In Group B, when the antecedent behavior was infant social approach, the appropriateness of the maternal profile (sensitive vs. intrusive responses) was related to their children's subsequent security. However, how promptly mothers responded was not predictive. Conversely, when the antecedent behavior was infant play, how promptly the mothers responded was associated with securely attached children while mothers' profile of appropriate responses did not distinguish the subsequent quality of attachment. The indices derived from state-space grids were associated with attachment type and distinguished Group C from Groups B and A. However, results from analysis of a specific region of states, "maternal interfering response to infant social approach," showed significant discriminant function that correctly classified 78% of Group B, 73% of Group A, and 83% of Group C. Group B infants received less intrusive behavior than their counterparts, and when they did, it involved positive affection or playfulness. Finally, regarding attractors, although more Group B dyads showed multi-stability of coexisting attractors, than Groups A or C, the differences were not statistically significant.*

Key Words: child attachment, maternal sensitivity, nonlinear dynamical systems, GridWare, state-space grid, early mother-child interaction

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INTRODUCTION

The quality of attachment has a critical effect on child's development. According to Attachment theory, early parent-child attachment security plays a central role in the promotion of social and emotional adaptation (Bowlby 1969/1982), and that adaptation endures over time (Sroufe, Egeland, & Kreutzer, 1990). Meta-analytic studies have found a significant role for early attachment security in the development of children's social competence with peers (Groh, Fearon, Bakermans-Kranenburg, van IJzendoorn, Steele, & Roisman, 2014; Schneider, Atkinson, & Tardif, 2001). Likewise, the meta-analyzed literature documents that insecure attachment is associated with higher risk of externalizing (Fearon, Bakermans-Kranenburg, van IJzendoorn, Lapsley, & Roisman, 2010) and internalizing symptoms (Groh, Roisman, van IJzendoorn, Bakermans-Kranenburg & Fearon, 2012; Madigan, Atkinson, Laurin, & Benoit, 2013). They have also found that this predictive significance of early attachment (in)security endures over the course of development from infancy into early adolescence (Fearon et al., 2010, Groh et al., 2012; Groh et al., 2014). Therefore, the quality of child attachment has a predictive value on child developmental adaptation.

Ainsworth made two major, and pioneering, contributions to the field of attachment: one methodological, the Strange Situation Procedure (SSP) for assessing infant attachment pattern classification (Ainsworth, Blehar, Waters, & Wall, 1978), and the Maternal Sensitivity construct, related to her focus on the origins of attachment security in early infant-mother interaction (Ainsworth, Bell, & Stayton, 1974). Both have been extremely influential in developmental research: SSP has been recognized as the standardized observational method in the assessment of child attachment (Solomon & George, 2016). The interactive origins of attachment (in)security attracted great interest in developmental psychology and major longitudinal studies were designed replicating and extending her research (Grossman, Grossman & Waters, 2005).

The SSP was devised for assessing individual differences in the quality of the parent–child attachment relationship in infants by capturing the balance between attachment and exploration. This laboratory situation allows for the examining of the way in which a baby's behavior, between 12 and 20 months of age, is patterned when the attachment system is activated, at varying levels of intensity, through simple manipulations of this environment (Ainsworth et al., 1978).

Using the SSP, Ainsworth et al. (1978) distinguished three main groups of attachment - a 'secure" group (B) and two insecure groups: "avoidant" (A) and "resistant" or "ambivalent" (C). The classification is based on the infant's behavior in the reunion episodes in the context of the whole procedure. The B-child recovers easily from separation and, upon reunion, engages in positive interaction, seeks and maintains contact, using the mother as a secure base for exploration. In contrast, upon reunion, the insecure-avoidant child (A), focuses more on the environment and objects, avoiding closeness with the mother,

showing little visible distress during the separation. The insecure-resistant child (C) during the separation episodes gets very upset and, upon reunion with the mother, shows strong proximity seeking and contact maintaining, but expresses anger; fails to find comfort in the mother but shows reluctance to separate from the mother, to resume exploration. Two subtypes in each insecure group, A1, A2 and C1, C2 and four for securely attached children, B1, B2, B3, B4 were also identified (for a detailed description see Ainsworth et al., 1978). Although the majority of children can be classified by these ABC criteria, a percentage were detected who presented without an observable goal, intention or exploration that prevented them from achieving the functional goal of the attachment system (Main & Solomon, 1986, 1990). The most characteristic feature of this group was their lack of a coherent attachment strategy. Consequently, this fourth group was termed "disorganized/ disoriented," type D, contrasting, therefore, with the organized secure and organized insecure patterns identified by Ainsworth et al. (1974) for which she developed the sensitivity construct.

The Maternal (In)Sensitivity to infant signals construct (Ainsworth et al., 1974) characterizes early mother-infant interaction. It was based on deep examination of individual differences in mother-infant dyads and its relationship with the development of child attachment. Ainsworth (1977) focused on identifying patterns of infant-mother behavior during the 9-12 month quarter because the number of differences that emerged were larger than in the first quarter. Although Maternal Sensitivity is a relational concept that involves infant's signals, however, the mother is the one responsible to create the mutual attunement in the dyadic interaction. For the conceptual development of the construct, see Bretherton (2013).

Maternal Sensitivity was related to the development of a secure attachment relationship (Ainsworth, 1973; Ainsworth, Blehar, Waters, & Wall, 1978). In the context of Attachment theory, the sensitive maternal response develops the infant's confidence in his or her mother's accessibility and responsiveness and, on these expectations, builds up the "working model" of the attachment figure (Bowlby 1969, 1973; Bretherton & Munhollan, 2016; Sherman & Cassidy, 2015). Over the years, the accumulated evidence (correlational and experimental, longitudinal and cross-sectional) supported that differences in child attachment security are systematically related to the quality of the interactive infant-mother history. (Belsky & Fearon, 2008; Fearon & Belsky 2016). Moreover, meta-analytic studies found that improvements in Maternal Sensitivity through parental interventions, improves child attachment quality (Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003).

Ainsworth developed 9-point scales to rate maternal care (Ainsworth et al., 1978; Bretherthon, 2013), and most studies in the field have used rating scales to assess Maternal Sensitivity (De Wolff & van IJzendoorn, 1997; Mesman & Emmen, 2013). According to this, the mothers of children who develop secure attachment, type B, are sensitive, consistent and prompt in responding to their infants. They also show low levels of intrusiveness, and can be distinguished from mothers of children who develop insecure attachment.

Thus, mothers of children with avoidant insecure attachment, type A, are more insensitive to their infants' needs, because they show under-involvement or intrusiveness (Belsky, Rovine, & Taylor, 1984); and, mothers of children with resistant insecure attachment, type C, are inconsistent in their response, sometimes sensitive and at other times non-nurturing (Cassidy & Berlin, 1994).

Meta-analytic studies consistently support the role of sensitivity as a predictor of infant attachment (Bakermans-Kranenburg, et al. 2003; De Wolff & van IJzendoorn, 1997; Goldsmith & Alansky, 1987). However, the effect sizes, ranging from small to medium, were lower than expected, depending on the measures used for sensitivity and attachment. This provides scope to pose the question whether the complexity of the "Maternal Sensitivity" construct has been appropriately addressed (Lohaus, Keller, Ball, Elben, & Vöelker, 2001; Shin, Park, Ryu, & Seomun, 2008). In this regard, two methodological considerations must be taken into account: firstly, Maternal Sensitivity as a construct is "evidenced in a variety of forms of behavior and not perfectly so in any one of them" (Nunnally, 1978, p. 84). Therefore, a more comprehensive approach is required. Secondly, most of the studies on Maternal Sensitivity have used rating scales or global judgments. In these macro-analytical approaches, the temporal dimension in the infant-mother interactive process is not explicitly measured.

The Maternal Sensitivity construct and the temporal dimension

The value in capturing the temporal dimension in the understanding of these infant-mother processes was pointed out even before the methods were properly developed (e.g. Stern, 1974) because it was understood that mothers *responding* to their infants' signals involved a time process. Moreover, developmental literature indicates that infants are sensitive to contingencies between their behavior and environmental events (Bigelow & DeCoste, 2003; Moore et al. 2009) as well as to the lack of them (i.e. the "still face" paradigm, Goldstein, Shwade, & Bornstein, 2009; Tronick, Als, Adamson, Wise, & Brazelton, 1978). The infant develops on-going expectations of sequences of events, within the self, within the "other" and between both. This procedural form of representation is based on the infant's experience of receiving a contingent response (Beebe et al., 2010; Beebe & Steel, 2013; Gergely, 2004; Tarabulsy, Tessier, & Kappas, 1996), It is on these procedural expectancies that the infant's internal working models of attachment are based (Beebe & Steele, 2013; Johnson, Dweck, & Chen, 2007).

Therefore, in the study of the antecedents of attachment research that includes the temporal dimension in analyses, micro-analytic studies have extended our understanding of Maternal Sensitivity (Beebe & Steele, 2013). Thus, subtle processes of face-to-face communication at 4 months have predicted attachment at 12 months. In particular, two aspects of Maternal Sensitivity, stimulation and contingency, were identified. Thus, the timing of mothers' stimulating their infants in relation to their infant gaze predicted secure attachment (Langhorst & Fogel, 1982; as cited in Beebe & Steele, 2013).

Considering that infants look away from the mother to down-regulate arousal (Field, 1981), not to stimulate them when they take a "break," shows maternal sensitivity to the infant's signal. Likewise, the level of stimulation and the level of contingency both showed that mid-range levels are predictors of attachment security (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Lewis & Feiring, 1989). For example, moderate levels of maternal contingency in facial coordination (Malatesta, Culver, Tesman, & Shepard, 1989) and moderate degree of correspondence with the child's rhythms of turn-taking (Jaffe et al., 2001), all predicted security, while higher or lower levels, were associated with insecurity.

These micro-analytic studies refer, in general, to coding of mother-infant interaction states in time-units of 1 second, and the usual setting of such studies is in face-to-face interaction with mother on a chair, facing the infant, who is secured in a baby seat. This face-to-face paradigm is not exempt from criticism. Mesman (2010) argued that this fragmentation of the coding segments, like 1-second units, contrasts with no time-frame free-play settings, typically used in macroanalytic approaches. Therefore, she questioned whether the two approaches were measuring the same construct.

However, the key aspect is the temporal dimension in the assessment, not the specific paradigm itself. Thus, the infant-mother interactive process in a free-play setting can be sequentially coded in real time, as the interaction unfolds, with no time-frame (Cerezo, Pons-Salvador & Trenado, 2008, Cerezo, Pons-Salvador, Trenado & Sierra, 2016). Likewise, in Bornstein and Manian's (2013) study, the authors used coding schemes for sequential interaction of free-play at home and with these data, identified a complex curvilinear contingency-sensitivity association between maternal contingent responsiveness and macro-independent global judgments of the same mothers' sensitivity. This pointed out that the construct of Maternal Sensitivity shows its complexity through different "windows" from which it has been glimpsed, using different methodological approaches and operational definitions, trying to capture aspects of it (Cerezo, Trenado, & Pons-Salvador, 2012).

Infant-Mother Sequential Interaction and Nonlinear Dynamics

Considering the temporal dimension in the infant-mother interactive process opens the door to another level of analysis. The nonlinear dynamical systems (NDS) framework has attracted the attention of system-oriented developmental psychologists, because NDS principles account for properties of dynamic, complex, adaptive, open systems (Prigogine & Stengers, 1984; Thelen & Smith, 1994, 1998). Therefore, assuming that a dyad is a dynamic system, NDS principles can account for behavioral patterns that emerge and stabilize through the system's internal feedback processes (Dishion, 2012; Hollenstein, 2007, 2013; Hollenstein, Granic, Stoolmiller, & Snyder, 2004).

The state-space grid (SSG; Lewis, Lamey, & Douglas, 1999; Lamey, Hollenstein, Lewis, & Granic, 2004, Hollenstein, 2007, 2013) is a tool to explore system dynamics and temporal patterns as they unfold over time. SSG is based on two NDS concepts (Hollenstein, 2007, 2013). First, the space of all

possible states of a system can be represented by a two dimensional grid. In this grid, the sequence of dyadic (infant-mother) behavioral states composes a trajectory that moves around the state-space grid, showing the states of the system as they change in time. The second concept is the attractor: In real time, attractors can be understood as absorbing states towards where the system, with all its possible states, tends to stabilize. Recurrent patterns of infant-mother interaction can be considered as a dyadic attractor that emerges over time (Granic & Lamey, 2002). In interpersonal relationships the multi-stability of the system, i.e. several co-existing attractors, has been examined by quantifying attractor states (Hollenstein, 2013). This multi-stability is related to the variability of the system: there is more variability in the system that moves from one attractor to another with moderate strength, than if there is just one strong attractor where the interaction tends to stay (Fogel, 1993; Lichtwarck-Aschoff, Kunnen, & van Geert, 2009). The SSG allows for examining simultaneous states (cells) but it can also be used to analyze lag-states (cells) by which the changes in "x" are followed by change in "y" (Hollenstein, 2013).

The NDS perspective has shown some potential in the exploring of Maternal Sensitivity in terms of overall temporal organization of infant-mother exchanges. Thus, using SSG indices, Cerezo, Trenado and Pons-Salvador (2012) reported some preliminary findings by which flexibility in the mother-infant interaction at 6 months distinguished secure from insecure children at 15 months and that, in terms of attractors, B-dyads showed from 6 to 12 months a decrease in number of attractors, which indicates an increase in self-organization, in contrast with the insecure dyads. A development of this study was to test the potential benefit in the prediction of attachment security of unpacking the verbal or non-verbal dimension of the coding system (Cerezo et al., 2016). The findings showed that flexibility obtained significant effects on child attachment for both the total grid, including verbal and non-verbal regions, and the reciprocal verbal region.

The Present Study

Two fundamental considerations constituted the basis of this study. Firstly, the theoretical relevance of explicitly including the temporal dimension and infant-mother contingency in the study of Maternal Sensitivity and, consequently, the interest of applying the NDS perspective. Secondly, the nature of Maternal Sensitivity as a construct that can be evidenced in a variety of forms that may need different strategies to capture them.

The mother considered highly sensitive, responds to her infant's signals "promptly and appropriately (…). Furthermore, she makes her responses temporally contingent upon the infant's signals and communications" (Ainsworth et al., 1978, p. 142; the description for the highest score of Sensitivity Scale). This maternal behavior is an *appropriate and prompt* response to either the infant's social signals or signals of need or distress (Ainsworth et al., 1978; Bretherton 2013; Keller et al., 1996). From this starting point the study was designed to assess Maternal Sensitivity in infant-mother interaction, using sequentially coded information in real time.

The infants' age was around 8 months for two reasons: Firstly, it was close to the infants' age studied by Ainsworth (1977) from which she developed the concept of Maternal Sensitivity. Secondly, because of the developmental changes in self- and other-awareness that takes place around that time and the significant developments in infants' social and emotional life experience due to the maturation of the higher limbic centers (Elliot, 1999; Fogel & DeKoeyer-Laros, 2007; Legerstee, 2005; Tomasello, 1993). These factors make this period particularly relevant for studying maternal sensitivity in the infant-mother interaction.

The assessment of Maternal Sensitivity in infant-mother interaction, using sequentially coded information in real time was carried out by examining "appropriateness," "promptness" and the dynamic of temporal organization of dyadic interactive processes. The study approached these three aspects of Maternal Sensitivity in relation to the quality of child organized-attachment, ABC groups:

1. *The appropriateness of maternal behavior* by examining the proportion of infant behavior to which the mother responded with sensitive vs. intrusive behavior, considering two different infant antecedents: social approach, and non-interactive behavior, i.e. play. By doing so the mother's behavior was "defined in a way that contingency on the action of the infant was preserved" (Maccoby & Martin, 1983, p. 20). It was predicted, for both infant antecedents, that the proportion of infant behavior followed by mother behavior coded as "sensitive," respecting infant's pace and space, would distinguish groups of attachment: B-infants, later securely attached children, would experience a higher proportion of their behavior followed by sensitive maternal response than infants from insecure groups, Avoidant and Resistant. In addition, inversely, B-infants' behavior would be followed by less intrusive maternal behavior than those of their counterparts.

2. *The promptness of maternal response*, by examining the latency of mother's response to the infant's social approach and infant play behavior. It was predicted for both antecedents that latency would distinguish attachment groups. Mothers of B-infants would show more prompt, shorter response latency to their infants' behaviors than mothers of A- and C-infants.

3. *The temporal organization of the infant-mother contingencies* using the NDS perspective was examined by using an SSG of infant-mother lag states. State-space grid cells that can represent simultaneous states, in this study are used to capture, change in "x" followed by a change in "y," in a two-step change sequence. Therefore, the state-space indicators of contingent sequences were used, i.e. the extension of SSG in SSG-LAG. The grid was analyzed in several ways to identify differences related to secure and insecure attachment styles. First, the overall grid was considered and then the particular regions of maternal intrusive response to both infant's social approach and play. It was expected that in both instances the combination of SSG derivative factors, lag-events and

visits, would discriminate attachment groups. Second, in terms of attractors, a higher proportion of multi-stability, which is associated with variability of the system, would be found in the dyadic interaction of the secure group. Finally, the content of the attractors and their relative strength was examined for exploratory purpose.

METHOD

Participants

The participants were 26 mother-child dyads, distributed in three groups according to the infant attachment types A (Insecure-Avoidant), B (Secure), and C (Insecure-Resistant) assessed when they were approximately 15 months of age (M = 61.25 wks., SD = 8.06). Eleven A-dyads, nine B-dyads and six C-dyads. These dyads interaction was assessed in a free-play session when the children were aged, on average, 8 months (M = 34.15 wks., SD = 4.48; range 27-42 wks.). Groups did not differ in child's age ($F(2, 25)$ =.24, p = .787). Most of the children were boys (80.77%). The five girls were distributed in the three groups, one in the A-dyads, and two in the B and C dyads, respectively. No dyads showed *any* disorganized attachment traits for type D (Main & Solomon, 1990).

The mothers and children came from the general population who joined a universal community program comprised of six trimestral center-based visits, to support parenting during the first two years of life (Cerezo & Pons-Salvador, 1999; Pons-Salvador, Cerezo, & Trenado, 2014). They were aware of the procedures and gave informed written consent for videotaping, both the free-play and the attachment test for analysis on which they received feedback. Additionally, they gave written consent for the anonymous use of their data for research purposes. The dyads came from two sites: Spain and Ireland. No differences regarding origin of the dyads were found between secure and insecure groups (χ^2 (2) = .59, N = 26, p = .443).

The average mother's age was 29.96 years (SD =4.65, range 21-39 years). Most of the mothers lived with the father of the child and 11.54% were single-parent families. The families had between 1 to 4 children (57.69%, one child; 30.77%, two children and 11.54% 3 or more; M = 1.61; SD = .89). Regarding mother's educational level, 19.23% of the mothers had primary studies, 53.85% secondary and vocational training and 26.92% third level education. Regarding occupations, there were 50% mothers working full time at home. In the 50% employed, 15.38% mothers worked in unskilled occupations, 26.92% in semi-skilled jobs, and, finally, 7.69% in each in qualified occupations

No differences among the three groups were found for any of the socio-demographic variables examined: mother's age, (F(2, 23 = 1.86, p = .178); educational level (χ^2(2) = 0.38, .28, N = 26, p =.820, .592), working at or out of home (χ^2(2) = 0.17, N = 26, p =.680), number of children (χ^2(2) = 0.00, N = 26, p =.960), or marital status (χ^2(2) = 0.48. N = 26, p =.487).

The 26 participants in this study came from a pool of 49 dyads. Firstly, these 49 participants in the program, who had given consent, met the following criteria: (a) The child's attachment with the biological mother, assessed at 15 months, was classified as A, B2, B3 and C. (b) Children's development was appropriate for their chronological age, assessed by the Developmental Scales of Knobloch, Stevens, and Malone (1980). (c) They completed only one or two free-play sessions in the program, which meant they had no intervention regarding their interaction. (d) The child's age ranged from 25 to 43 weeks. The pool consisted of 16 children classified as A-type (subtypes A1 and A2), 18 children as B-type, B2 or B3, and 15 children as C-type, C1 and C2. Secondly, Judith Solomon, co-author of the discovery of Disorganized Attachment, (Main & Solomon, 1986, 1990) examined this pool of children with a double purpose: firstly, to provide expert reliability for the classification, and secondly, to identify any D traits in these children. In ABC cases, some disorganized behaviors listed by Main and Solomon can be present although they do not show the intensity or cross the threshold to give the child the status of type D attachment (Granqvist et al., 2017). In the D-Scale from 1 to 9 the cut-off score for type D is 5 (Main & Solomon, 1990). For the purpose of the present study the criterion was that the participants were prototypical of organized attachment, therefore the children should show *no D* traits in the SSP, and only central subtypes B2 and B3 in secure attachment were considered. The outcome of that examination was as follows:

From the original 16 A-children, 14 out of the 16 were classified as A-children. Eleven of them presented no D traits, three children showed D traits, two below and one over the cut-off score. Two cases were classified as B2, one of them with no D traits. The agreement obtained for A-type classification was: 87.50%

All of the original 18 B2 and B3-children were classified as B children. Eight children were classified as B2 or B3 with no D traits; two more children, B2 and B3 showed D traits below the cut-off score; three children were B with no D traits but the subtype was not clear. Five more were type B but with changes in the subtype, four of whom were B1 and one was B4, no D traits either. The agreement obtained for B-type classification was 100%.

From the original 15 C-children: 13 were classified as C-children. Six children were classified as C with no D traits, seven more C-children showed D-traits, 5 below and 2 over the cut-off score, and two children were classified as B4. The agreement obtained for C-type classification was: 86.67%. This was consistent with the observation that it is more common to find D traits in C pattern than in the others (Granqvist et al., 2017; van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999).

The final group of 26 dyads consisted of those that included children with A (n = 11), B2 and B3 (n = 9) or C (n = 6) attachment with no D traits. For secure type only B2 and B3 were included. For the insecure types, A and C, the selection included the two subtypes A1 and A2, and C1 and C2, respectively.

Procedure

Free-Play Sessions

In the context of the visit to the Program, the mother and the infant were asked by the professional to play in a room with a chair and a table with a matt and some toys. The instructions were to play as she usually does and that it was optional to use the toys. The play session was 4-5 minutes long, which is considered sufficient for the systematic observation with infants (Kemppinen et al., 2005). All mothers played with their child on the table or on their lap. The session was videotaped as part of the routine of the Program for coding and analysis. There were no significant differences among the groups in the duration of the free-play sessions: (M = 250.65 sec., SD = 52.67, $F(2, 23) = 0.25$, p = .781). Twenty-six episodes representing approximately 108 minutes of observation were collected.

Attachment Assessment

When the child visited the Program at 15 months of age, the Strange Situation Procedure (Ainsworth et al., 1978) was carried out with the child and the mother in the context of the Program routines and was videotaped for coding and analysis. The procedure consists of eight three-minute episodes (for the specific instructions see Ainsworth et al. 1978, p. 323–324). The parents were informed, in advance, and were aware of the procedures. They gave inform written consent to be videotaped in both the free-play and in the attachment tests. This study was approved by the Research Ethics Committee of the University of Valencia.

Instruments and Measures

This study examined the mother-child interaction, recorded at 7.8 months of age of children who, later at 15 months of age, were assessed and classified according to the quality of their attachment. There were three sets of variables: the classification factor, the attachment type, the observational variables and the NDS variables. Therefore, the study, according to its objectives, used the following instruments and measures:

Strange Situation Procedure

The SSP is a situational test designed to assess the quality of child attachment in children aged between 12 and 20 months. The procedure lasts about 20 minutes in consecutive eight three-minute episodes that create conditions of increasing, but moderate, stress: interactions between the mother and the baby in an unfamiliar environment, encounters with a stranger and brief separations and reunion episodes with the caregiver. Coders, specifically trained, observe the child's behavior towards his or her mother in the two reunion episodes, in the context of the other episodes. They also rated the child's behavior on four 7-point scales of the dyadic interactive behavior that are used in the process of classification: seeking proximity and contact, contact maintenance

Table 1. Categories in the Early Mother–Child Interaction Coding System-Revised, CITMI-R.

Child Categories	
Interactive	*Social approach (A):* Social approach, verbal, or non-verbal, to the parent as a response to her/him or as a child's initiative. It has three affect or valences: positive, neutral, and negative.
Non-Interactive	*Solitary play (J):* The child is involved in his/her own game with or without a toy; she/he is clearly demonstrating interest in the exploration.
	Solitary crying or whining (L): The child express general discomfort usually related to being tired, sleepy or hungry.
	Passive/disinterested/apathetic behavior (Pa): The child shows a bored or non-attentive facial expression. If the child ever catches hold of something there is not looking at it or exploration.
Parental Categories	
Interactive	*Sensitive (S):* Social approach, verbal or non-verbal, that meets the demands of the situation and is appropriate for the age, abilities and interests of children. This approach DOES NOT interrupt child's ongoing activity, or intrude in child's space. It includes proposals of toys or games to the child in a way that the child has a choice to accept it or not. It has two affect or valences: positive and neutral.
	Intrusive (T): Social approach, verbal or non-verbal, that interrupts on-going activities of the child or invades his space and it is not meeting child's needs. It includes proposals of toys or games to the child in a way that the child has no choice or they are above child's skills or reach, like putting a toy in his hand, or too far away. It has three affect or valences: positive, neutral, and negative.
	Protective-intrusive (P): Social approach, verbal or non-verbal that interrupts child's ongoing activity, or intrudes in child's space with the aim of protection or help. It has three affect or valences: positive, neutral and negative.
Non-Interactive	*Indifferent/non-response (F):* Lack of interaction with the child showing lack of attentiveness and lack of facial expression, or the parent looks away not responding to child's approach.

avoidance, and resistance to contact and interaction. The coders classify the type of attachment according to the similarity of child's behavior with the prototypical characteristics indicated by Ainsworth et al. (1978, p. 59-63) for

each group. SSP is the gold standard for child attachment assessment and "the reliability and predictive validity of Ainsworth's classification measure are well established in US and Western European populations" (Solomon & George, 2016, p. 373). The traditional, three-category classification developed by Ainsworth et al. (1978) – secure (B), insecure–avoidant (A) and insecure–resistant (C) operationalized the grouping factor for the dyads whose interactions were examined. Therefore, the groups of dyads under study were named Group-A, Group-B, Group-C.

Four trained graduate students in Psychology were the coders in this study. The training consists of 35 hours that includes the following: knowledge of attachment theory, understanding of the rationale for, and guided scoring of, the rating-scales, individual practice of assessment of attachment: with types and sub-types. And feedback for their ratings and classifications, individually and in group. The final part consisted of a monitoring phase. The coding was done by coders trained by two of the authors who have had their coding reliability established by the Institute of Child Development of Minnesota. By the end of the training, reliability analysis was carried out with pre-coded cases: coders obtained above 90% of agreement in ABC attachment types.

Fig. 1. Illustration of CITMI-R computerized coding system applied to a free-play recording.

The Early Mother-Child Interaction Coding System *(Códigos para la Interacción Temprana Materno*-Infantil: CITMI-R; Trenado & Cerezo, 2007) was devised for children from 0 to 24 months. The structure and coding rules are based on the Standardized Observation Codes III (SOCIII; Cerezo, 2000), of which the CITMI-R is its version for early interaction. Therefore, the CITMI-R categories, which are based on maternal sensitivity dimensions, are mutually exclusive and exhaustive; they record the behavioral interactive stream in observational data susceptible to microsocial and sequential analysis. Table 1 shows a descriptive summary of CITMI-R.

The frequency, duration, sequence and valence of the exchanges were recorded using a specially devised computerized coding. This system allowed the coders uninterrupted codification in real time (Fig. 1).

The CITMI-R has shown good standards in terms of psychometric properties in criterion validity and content validity with dyads from Ireland, Spain and Brazil (Alvarenga & Cerezo, 2013; Cerezo, Sierra-García, Pons-Salvador & Trenado, 2017; Trenado, Pons-Salvador & Cerezo, 2014). These studies have analyzed inter-observer reliability using statistics such as the CCI with values ranging from .67 to .94, and Alignment Kappa (Bakeman & Quera, 2011), values ranging from .61 to .96. All the values reached statistically significant levels, supporting the reliability of the instrument.

Six trained coders who obtained accuracy levels in their training above a cut-off of 60% were the CITMI-R coders in this study. The 25-hours of training, following the CITMI-R training protocol (Trenado et al., 2014), included theory and practice with recorded mother-infant interaction in a free-play setting of increased difficulty. Alignment Kappa (Bakeman & Quera, 2011) applied as a test of reliability for monitoring the training process. This method identifies commission-omission errors.

CITMI-R includes four categories for infant behavior, one interactive and three non-interactive, and four categories, as well, for the maternal behavior, three interactive and one non-interactive. All interactive behaviors can be coded as being either positive, neutral or negative, except for “Sensitive” maternal behavior that can only be either neutral or positive affect, by definition and nature. The observational variables were: rates per second, for both infant and mother behaviors. In the case of infant’s behaviors, neutral, positive and negative social approaches were collapsed into a category: Infant Social Approach, for which the rate per second was computed. Additionally, for maternal response, relative frequencies and latency of response to particular infant antecedents were also computed. In particular, the latency of maternal response was computed by subtracting the time entry for the each of the mother’s responses from the time entry of the immediate child antecedent behavior.

State-Space Grid Measures

The State-Space Grid (SSG; Hollenstein, 2013; Lamey et al., 2004). SSG is a graphical approach that utilizes observational data. The dyad’s

trajectory, the sequence of behavioral states is plotted as it proceeds in real time on a grid representing all possible behavioral combinations. The codes for the infant (x-axis) and the parent (y-axis) were represented on a quasi-ordinal scale from the most positive to the most negative. The unit was the dyad as an open, dynamic, self-regulating system. The state-space grid for this study consisted of 54 (cells), any combination of the six infant codes by the nine maternal codes.

The cells can represent simultaneous states or, in the case of SSG-LAG, cells capture, in a two-step change sequence, change in *"x"* followed by a change in *"y."* In this study, we used the state-space indicators of contingent sequences, that is, the extension of SSG in SSG-LAG. The variables capture temporal patterns as they unfold over time and the measures derived from the SSG-LAG data were:

Frequency of Lag-Events: A lag-dyadic event corresponds to a single node in a particular cell capturing a two-step change sequence: change in *"x"* (child) followed by a change in *"y"* (mother). These dyadic events are the smallest unit displayed on the grid with an onset and offset, which can have different durations, and it is a content-independent measure.

Frequency of Visits are changes from one cell to another, a cell visit beginning upon a trajectory's entry into the cell, or a group of cells, a region, and ending upon its exit. It is a content-independent measure. There can be one or more consecutive events occurring within a single visit. Frequency of Lag-Events and Frequency of Visits are time dependent, the longer the observation the more opportunities. Consequently, it is recommended that these variables be divided by the total duration of the trajectory – time observed in each dyad – as it can be slightly different for each dyad. Thus, the measures were converted into rates per second: *Lag-Events rate* and *Visits rate*.

When there are no consecutive or repeating events, the *Ratio of Lag-Events per Visits* ratio is 1.00. The higher the ratio, the more repetitive events take place within a visit.

The identification of *attractors* for each dyad followed several steps: (a) The duration of each trajectory divided by its grid range provided the *Mean Duration per Cell*. (b) The actual amount of session time spent in each particular cell was computed. This was the cumulative duration per Lag-state that each dyad visited. (c) The standard deviation (SD) of the amounts of time spent in all the cells visited by the dyad was computed. (d) Finally, an attractor was defined as that Lag-state that showed a duration value higher than the value of the Mean Duration per Cell plus 1 SD. For example: a given dyad had a Mean Duration per Cell of 41.68 sec and a SD, considering all the states where this dyad spent some time, of 56.59 sec. Therefore, any state with time longer than 98.27 sec. (Mean +1 SD) was considered as an attractor for this particular dyad.

Return time derived from GridWare measures as the latency, in units of time, to return to the identified attractor. Return time was the average duration of the intervals between visits to the attractor and it was used as measure of its strength. Low return times indicate a strong attractor; high return times indicate a weak or non-existent attractor.

Reliability Tests for Measures

Interactive Measure

The quality of the data coded from the free-play was validated, by randomly allocating 27% of the free-play episodes to a second independent coder. All coders were unaware of the purpose of the study. For the purpose of the reliability analyses, the second coding had the same length as the first, to avoid differences between the outputs in the length of the coded observation. The observation total time across the seven dyads was 25.23 minutes (M = 3.60, SD = 0.28). Specifically, for the reliability analysis of the measurements obtained by CITMI-R, two approaches were used:

Firstly, to calculate the agreement between coders, a detailed analysis for the coding was computed using Alignment Kappa (Bakeman & Quera, 2011). This method identifies commission-omission errors and is based on an algorithm that determines the optimal global alignment between two single code event sequences. The mean of kappa statistic for the 7 episodes analyzed, and for all categories, was .55 (SD = 0.07). The kappa values are influenced by the number of codes of the coding system and by the prevalence of these codes. CITMI-R has 15 codes with high prevalence variability. Therefore, a kappa value of .55 equals a greater than 72% accuracy (Quera, Bakeman, & Gnisci, 2007).

Secondly, the main variables under study derived from SSG were considered to test the reliability. The Pearson correlations were computed for "Lag-Events rate," r_{xx} = .88, mean scores for coders 1 and 2: 0.48 (SD = 0.07), and 0.53 (SD = 0.12); for "Visits rate;" r_{xx} = .92, mean scores for coders 1 and 2: 0.22 (SD = 0.04), and 21 (SD = 0.03). All the correlation values were statistically significant ($p < .01$).

Attachment Measure

For attachment classification, all the 26 cases were selected meeting the criterion of no presenting D traits from a pool of 49 cases. The reliability for attachment classification for *all the forty-nine cases* was of 85.71% with the criterion or expert Judith Solomon.

Data Analyses

Two-way MANOVAs (Multivariate Analysis of Variance) were conducted to examine the effect of group membership factor, type of attachment, on infant's behavior and latency of maternal responses to infant behaviors. ANOVAs (Analysis of Variance) were also conducted. F ratio values with p and effect size eta-squared values, h^2, were reported. The assumption of homogeneity was tested by computing variance Levene's test and non-parametric tests were conducted when the assumption of homogeneity was not met. For post-hoc analysis, Bonferroni t-tests were used to guard against Type I error. A Games-Howell test was used when there was no homogeneity of the

variances (Ruxton & Beauchamp, 2008). Chi-square tests of goodness-of-fit were performed to determine if the grouping factor of attachment was related with the distribution of different maternal responses to their child behavior and with quantity and type of attractor.

The GridWare software (Lamey et al., 2004) was used to carry out the dynamic analyses. The State-Space Grid (SSG) software (Hollestein, 2013, Lamey et al., 2004, Lewis et al., 1999) was used to derive dyadic interaction variables. The GridWare File Converter 1.0 was used to create the lagged state variable for the maternal behavior and all the subsequent analyses were computed on the converted files by which each dyadic event (cell) includes the sequence: infant behavior (plotted on x-axis) at time 1 and the mother response at time 2 (plotted on y-axis) to it. SSG derived variables were used in a discriminant analysis to predict the type of attachment. All data analyses were performed using the SPSS v.20.0 statistical package for Windows.

RESULTS

The early mother-child interaction is a particular interpersonal process in which the observation of contingent changes shed light on the influencing process involved, in particular, the Maternal Sensitivity construct. This framework allows studying the sequences of infant behavior and subsequent maternal response from different aspects. The results are presented in three sections related to the three corresponding aspects, preceded by a preliminary analyses section. Firstly, analyses of the profile of maternal responses to the infant's categories interactive and non-interactive. Secondly, the analyses on latency of maternal response, promptness, to infant's behavior. Thirdly, the lag-state space NDS indicators of temporal patterns in the overall grid, the intrusiveness of maternal response and the attractors.

Preliminary Analyses

Given that the coding in real time starts with the child and from then any behavior from the child, or toward the child by the mother is coded as the interaction unfolds back and forth, there is the possibility of two child's consecutive codes. There are two possibilities: "Interactional, Approach (A), followed by Non-interactional, Play (J)" or vice versa. Examples: for the first case, Child plays, coded as "Play (J)"; Mother says: "Here is the truck," pointing to a toy beside the child, coded as "S"; the child looks at that toy "A" then starts playing with it ("J"); the Mother says: "It is nice" (S); coded sequence: "J,S,A,J,S." For the second case: Child looks at Mother (A), Mother smiles: "How is my baby today?" (Sp), child focuses in getting a toy (J); then child looks at his or her mother (A); and Mother says: "Yes, you like that toy" (S): sequence coded as "A,Sp,J,A,S."

There are very few instances of these two child consecutive codes. Data outputs were examined to detect these behaviors, and *in each case the first of the*

two codes was tallied and rates per second were computed, for both Approach, any valence: positive, neutral or negative and for Play codes. In order to proceed with the study of infant-mother sequences and attachment type, firstly, it was analyzed whether these codes showed any association with the grouping factor.

Two-way MANOVA to test the attachment group membership factor on this infant's Social Approach rate (M = 0.04, SD = 0.02) and Play rate (M = 0.003; SD = 0.004). MANOVA showed no multivariate effect for attachment group on this particular infant's behavior measures ($F(4, 44) = 0.54$, p =.710, Wilk's Λ = .909, h^2 =.046). Levene's Tests results showed the data met the homogeneity of variances criterion.

Therefore, these instances were eliminated from the files for the study of the sequences. All the subsequent analyses were conducted on the stream of sequences infant behavior-mother response.

Infant –Mother Interaction Sequences: Maternal Appropriateness in Response Profiles

As a preliminary step to studying the maternal profile of responses to infant behavior, the rate of Infant Social Approach and the rate of Play were computed. The two-way MANOVA to test attachment group membership factor on the infant's Social Approach (either positive, neutral or negative) rate and Play rate, showed no multivariate effect for attachment group on infant's behavior measures ($F(4, 44) = 1.16$, p =.342, Wilk's Λ = .818, h^2 =.091; Levene's test for Approach rate $F(2, 23) = 0.095$, p =.909, Levene's test for Play rate $F(2, 23) = 1.50$, p =.243). As a further step, two chi-square tests of goodness-of-fit were performed to determine whether the three types of maternal responses (sensitive, S, intrusive, T or protective-intrusive, P) were equally distributed in the three attachment groups, one after infant's interactional behavior and one after non-interactional behavior, i.e., play.

Maternal Response to Infant's Social Approach

The type of maternal responses to infant Social Approach did not show similar distribution among the three attachment groups (χ^2 (4) = 16.65, N = 26, p = *.0006*). In the group of B children their social approaches were receiving a higher proportion of sensitive attention from their mothers (83%) than their counterparts in Groups A (75%) and C (65%), insecure attached children (see Fig. 2).

As regards the behaviors that we can describe as intrusive (T and P), a greater percentage stands out in the insecure groups (Group C: 35%, Group A: 25%), than in Group B (17%). Additionally, for infants from Groups A and C when their mothers responded intrusively to their Social Approach, they used T behaviors more than P behaviors that were aimed at protecting the baby (Group C: 21% vs. 13% and Group A 16% vs. 9%). However, for the infants from Group B when their mothers, who were less intrusive, presented these behaviors, the proportion of Ts and Ps was similar: 9% vs. 8%.

Furthermore, regarding the type of affect in maternal intrusive responses, while Protective-intrusive behavior was usually neutral in the three groups (as more matter-of-fact, such as fixing clothes, changing child's position), Intrusive behavior showed instances of both positive and neutral affect. The infants from the insecure attachment groups were responded to more frequently by T neutral than positive: (Group A: 9% vs. 7%; Group C: 13% vs. 8%), while infants from Group B received as much as twice T positive (6%) than neutral (3%). Finally, the "Mother no response" (F) to infant Social Approach is a behavior of very low frequency in the free-play setting, note that the only one coded was registered in a C dyad (Fig. 2).

In the free-play sessions there were very few occurrences of Social Approach coded as being negative in affect when the child is protesting or complaint. Interestingly, those few instances when they took place, if the dyad was from Group B, 95% of them were responded by Sensitive maternal approach, and 5% by Protective-Intrusive, while this proportion was 50-50 when the dyad was from Group A. In turn, if the dyad was from Group C, in those few instances of infant's negative Social Approach 25% of them were responded by Sensitive approach, 25% by Protective-intrusive and 50% by Intrusive behavior.

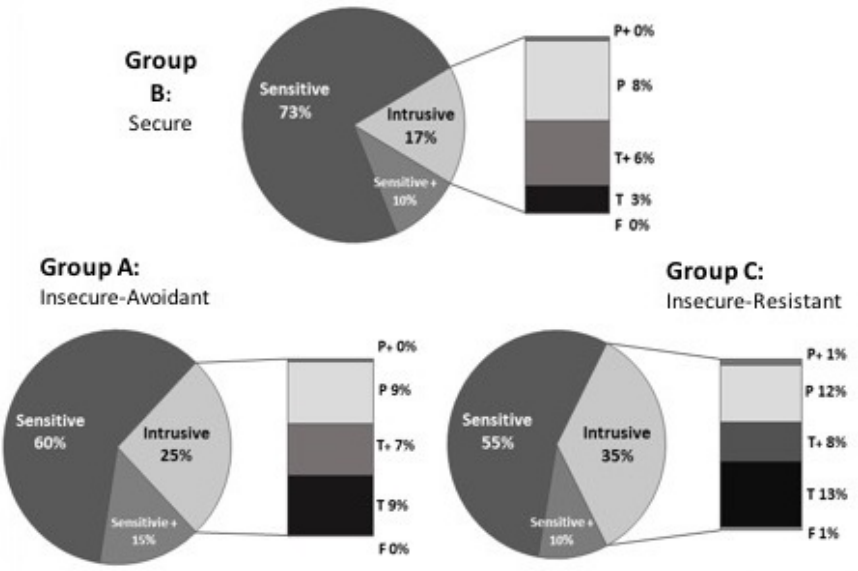

Fig. 2. Appropriateness of Maternal Response to Infant Social Approach (positive, neutral or negative) in the free-play at 8 months considering the dyad membership to the A, B and C attachment groups at 15 months. P = Protective-Intrusive, T = Intrusive, F = no response, and '+' for positive valence.

Maternal Response to Infant's Play

To determine if the grouping factor of attachment was related with the distribution of three types of maternal responses (sensitive, S, intrusive, T or protective-intrusive, P) to their children's Play behavior, a chi-square tests of goodness-of-fit was performed. The results showed that the children from the three attachment groups received a similar distribution of their mothers' responses, in terms of sensitive, intrusive or protective-intrusive behaviors, χ^2 (4) = 2.05, N = 26, p = *.726.* The most frequent response to child's play was Sensitive, neutral or positive, across the three attachment groups: Avoidant: 80%, Secures: 79% and Resistant: 78%.

Summary

These results suggest that the differences pivoted more on the responses that were given to the child's social behavior, rather than to the play behavior. Moreover, given that children were similar across the groups in their social interactive behavior, the differences associated with the type of child attachment relied on the maternal responses. A child from Group B socially approaching her or his mother received significantly more sensitive responses than their counterparts did in insecure attachment groups. Inversely, this child was less frequently responded to by intrusive behavior and, when that was the case, the intrusiveness was accompanied with positive affect.

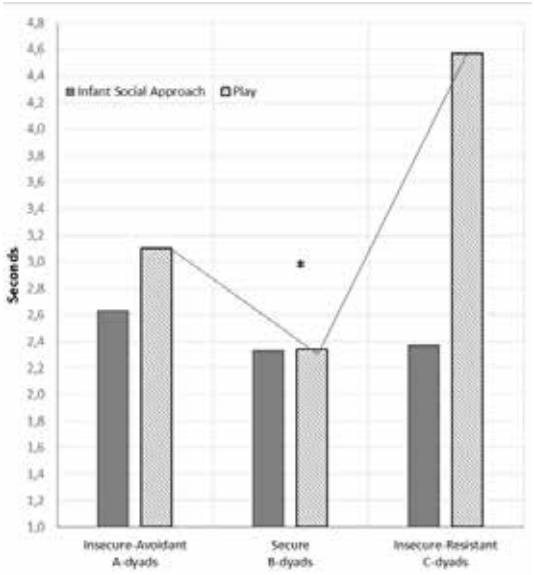

Fig. 3. Latency of maternal response to infant behaviors: "Social Approach" and "Play" in the three attachment groups; * p < .05, both among the three groups and between secure and insecure groups.

Infant –Mother Interaction Sequences:
Latency of Maternal Response

The latency of maternal response (LMR) was computed by subtracting the entry time of the coded maternal behavior from the entry time of previous infant behavior. Thus, the duration of the infant behavior showed the mother response latency: how prompt was the maternal behavior in responding to her child's behavior. The LMR was computed for both, responses to Child's Social Approach and also for those ones to Child Play, non-interactional behavior (Fig. 3).

The two-way MANOVA to test attachment group membership factor on the two LMRs, to child Social Approach and to Play showed a multivariate effect, $F(4, 44) = 2.90$, $p = .032$, Wilk's $\Lambda = .626$, $h^2 = .209$. The results indicated no differences among the three attachment groups for mothers' promptness to their child's Social Approach $F(2, 23) = 0.60$, $p = .553$, $h^2 = .050$. In contrast, there was a significant effect for LRM to Play, $F(2, 23) = 4.42$, $p = .024$, $h^2 = .278$. However, the assumption of normality was not met for the LMR to child Play (Levene's test for LRM to A: $F(2, 23) = 1.88$, $p = .175$: Levene's test for LRM to Play: $F(2, 23) = 21.86$, $p < .001$). Therefore, non-parametric tests were applied for this variable.

The non-parametric Kruskal-Wallis test for three groups showed a statistically significant difference between the LMR to play showed by the different attachment groups of mothers ($H(2) = 7.21$, $p = .027$) with a mean rank of 8.33 for Secure Group, 14.91 for Insecure-Avoidant Group and 18.67 for Insecure-Resistant Group.

Subsequent analyses were conducted grouping secure vs. insecure children for the LMR to Play. A Mann-Whitney test indicated that mothers from the insecure children group showed greater latency of response to their children's play (mean rank 16.24) than mothers from the secure children group (mean rank 8.33), $U = 30$, $p = .012$. Further analyses showed that, specifically the mothers from the Secure Group were more prompt in their social sensitive response to their children's play than their insecure counterparts (mean ranks: 8.90 vs. 15.94; $U = 35$, $p = .025$).

In summary, these results suggest that promptness in maternal response to infant behavior was relevant in distinguishing attachment groups in relation to the child's play. When children were focused on objects or toys, if they were from Group B their mothers responding to them more promptly than if they were from Groups A or C. Specifically, their mothers responded promptly with sensitive social approaches, which may point to them being more attentive.

Infant –Mother Interaction Sequences:
Dynamic Lag-State Space analysis

In the overall analyses for grid total lag-states, the MANOVA multivariate contrast results show that the set formed by the variables Lag-

Events rate,Visits rate, and the Ratio of Events / Visits presented differences in relation to the grouping factor (A, B and C), ($F(6, 42) = 3.08$, $p = .014$, Wilk's $\Lambda = .482$, $h^2 = .306$). These results were for the combination of the three variables, and univariate tests for between-subjects effects showed no significant differences considering each of the variables separately (Lag-Events rate: $F(2, 23) = 2.01$, $p = .157$, $h^2 = .149$; Visits rate: $F(2, 23) = 0.04$, $p = .965$, $h^2 = .003$; Ratio of Events / Visits: $F(2, 23) = 2.45$, $p = .108$., $h^2 = .176$). The combination showed that in particular, the Group C distinguished from Groups B and A; the latter two groups did not distinguish from each other.

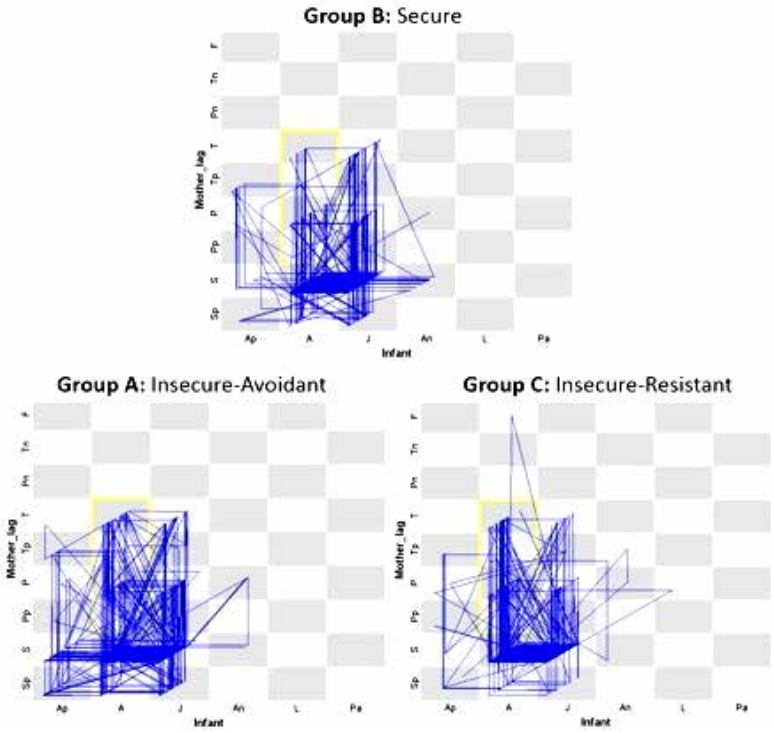

Fig. 4. State-Space Grids representing the trajectories of all the dyads in each group. The region 'Infant Social Approach' - 'Maternal Intrusive Behavior' is also represented in the Grids within the marked area corresponding to coordinates x2y3, x2y4, x2y5 and x2y6.

Lag-State Regions of Mother Intrusiveness to Child Social Approach and Child Play

Discriminant analyses were used to determine the linear combination of the NDS variables, which best classified the 26 children into each of the three attachment groups. Therefore, based on a discriminant analysis of the Lag-

Events Rate and Region Visits Rate, the functions were derived for the regions of Maternal Intrusive Response both to child's Social Approach, and to Play. The eigenvalues, relative variance, canonical correlations and significance tests are shown in Table 2.

As the table shows, significant function was found for Maternal Intrusive Response to child's Social Approach region that explained 89% of the variance while the function for the Maternal Intrusive Response to child's Play

Table 2. Discriminant Analyses for the two GRID Regions.

Function	*Eigen-value*	*Pct* s^2	*Canonical correlation*	*Wilk's Lambda*	c^2	*df*
Child's Social Approach-Maternal Intrusiveness Region						
1	2.258	88.7	.849	.211	29.61*	18
2	.327	11.3	.497	.753	5.38	8
Child's Play- Maternal Intrusiveness Region						
1	.094	64.5	.290	.872	2.87	10
2	.051	35.5	.219	.952	1.03	4

*$p < .05$

explained 65% of the variance and was non-significant. Likewise, the variance in the dependent variable accounted for by these models was 72% and 8% for the region related to child's Social Approach and Play, respectively (Fig. 4).

In the classification results based on the significant discriminant function as predictor, 77% of the original group composed by three groups of attachment was correctly classified by using the discriminant function based on the Lag-Event rates that comprised the region of Maternal Intrusiveness to child's Social Approach and the rate of Visits to it. Specifically, 73% of all the dyads from Insecure-Avoidant Group, 78% of all the Secure Group and 83% of all the dyads from Insecure-Resistant Group were correctly classified.

The results regarding the functions at group centroids showed that the Secure Group displayed very few instances of intrusive behavior (low mean value: -0.16) and visits to this region. In contrast, the dyads that showed the highest rates in intrusive behavior and visits were classified as Group C (high and positive mean value: 2.61) and finally Group A showed a higher and negative mean of -1.29. Specifically, if the mothers acted in an intrusive manner in response to the infant's social approach, the case was likely to be classified as belonging to Group C. In particular, they have a higher rate of visits to the region and a higher "Social Approach, neutral – Mother Intrusive, neutral" (AT rate). In Group B, the rate of visits to the region was the lowest. So, it occurs rarely but if the dyadic event involved positive affect ["Social Approach,

positive – Mother Protective Intrusive, neutral" (Ap–P rate) or "Social Approach, positive – Mother Intrusive, positive" (Ap–Tp rate)] it was more likely to be classified as Group B. Finally, in the case of Group A, the visit rate to the region is a little higher than in the case of B. It should be noted that in the case of instances of "Social Approach, positive – Mother Intrusive, neutral" (Ap–T rate) the dyad classified as Group A.

Attractors in the LAG Infant-Mother Dyadic Interaction

Attractors, as a stable patterns of sequence of dyadic behavioral states (cell) that absorbs the system from other potential states was defined by two GridWare-derived measures: relative time spent in the specific behavioral sequence and return time to it, i.e. how fast the dyad came back to that cell. The first approach provided the number of attractors that subsequently were also analyzed considering their content, the second approach by using the latency to return to the selected cell was a measure of attractor strength.

Regarding quantity and content of attractors and attachment groups, the dyads from Group B showed a higher average number of attractors (M = 1.67, SD = 0.50) than those from Groups A and C (M = 1.36 and 1.17; SD = 0.50 and 0.40, respectively. Thus, 67% of the B dyads showed two attractors, in contrast with 36% dyads in Group A and 17% in Group C. These differences between secure B dyads and insecure, A and C dyads, were marginally significant χ^2 (1) = 3.35, N = 26, p = .067.

In terms of content and qualitative patterns, in all three groups of dyads, most of all attractors, 89.2%, were comprised of "child's play-mother's neutral sensitive approach" (JS) and "child's neutral approach-mother's neutral sensitive approach" (AS). Regarding the JS attractor, the grouping factor, attachment type, showed that the number of dyads that had this attractor was equally distributed (χ^2 (2) = 0.11, N = 26, p = .947). Therefore, similar number of dyads across the groups had JS attractor (A: 72.7%; B: 66.7%; C: 66.7%). Regarding the AS attractor, the three groups showed marginally significant differences (χ^2 (2) = 5.41, N = 26, p = .067). However, Group B dyads showed a significant higher number of AS attractor than Group C dyads (77.8% of the group vs. 16.7%; χ^2 (1) = 5.40, N = 15, p = .020, p <.05 by Fisher's exact test).

Return Time

Return time is the average duration of the intervals between visits to the selected cell. The dyad that comes back quickly to the specific behavioral sequence shows low "return time," which indicates that, this sequence is a strong attractor for them. In contrast, a high return time indicates a weak or non-existent attractor.

To explore the possible effect of attachment grouping on the strength of the identified attractors, in terms of return time, a first analysis was conducted where those dyads with two attractors were introduced with the average of the

two return times associated to them. Results showed a similar level of strength across the groups: $F(2, 23) = 0.25$, $p = .778$, $h^2 = .022$).

Further analyses explored the relative strength of the specific attractors "AS" and "JS." The dyads from Group A showed significantly higher strength for the attractor of maternal social response to child's Play ('JS": $M = 10.25$, $SD = 3.15$) than to the attractor involving this response to child's Social Approach ("AS": $M = 16.38$, $SD = 3.99$). Once they leave the cell they were quicker in coming back to "JS" than in returning to "AS," $F(1, 12) = 10.41$, $p = .007$, $h^2 = .464$). In contrast, for the children from Group B the two attractors, AS ($M = 13.58$, $SD = 2.08$) and JS ($M = 14.15$, $SD = 2.08$), were similar in their strength ($F(1, 12) = 0.03$, $p = .875$, $h^2 = .002$). Regarding the Group C, all dyads but one had only one attractor. Therefore, most of children in this group were not exposed to content by strength possible differences.

Summary

These results suggest, regarding the overall grid of lag-states, that the combination of three NDS indices: the number of infant-mother behavioral sequences, the changes from one sequence to another, and the number of consecutive events occurring within each visit, showed significant association with attachment quality. Additionally, the results suggest that the pattern of intrusive maternal response in relation to children's interactive behavior is more relevant than to their children's play. Thus, the different rates of infant-mother sequences regarding the maternal intrusive response to her child's approach and the changes among these types of sequences correctly classified 77% of the original group. Finally, the different possibilities of contingencies tended to stabilize in attractors. The B-dyads showed multi-stability in higher proportion than insecure dyads, that is, more than one coexisting attractors, although these differences did not reach statistical significance. The attractor "Child social approach – Maternal Sensitive" was significantly more common than in C-dyads. Additionally, for a child from Group A, the dyad was quicker in returning to the attractor involving his or her non-interactive, rather than interactive, behavior. In contrast, for B-dyads the two attractors showed similar strength.

DISCUSSION

This study examined eight-month old infants interacting with their mothers, in a free-play setting, using as a grouping factor the organized attachment patterns, A, B, or C, with no D traits, that they subsequently developed at 15 months. The main purpose of the study was to analyze Maternal Sensitivity in the interaction of these three groups using the sequential dyadic stream of infant's actions and the maternal responses to them. This was carried out through three aspects: appropriateness, promptness and examining the dynamic of temporal organization of the dyadic interactive process. The sequential dyadic process allows approaching the infant's actual experience on which expectancies are developed (Bretherton & Munholland, 2016; Beebe et al., 2013).

From the infants' perspective, our results showed that when they socially approach their mothers, if they were from Group B, their approaches were significantly more likely to be responded to with "sensitive" maternal responses (83%) than if they were from Group A (75%) or C (65%). Inversely, less of their approaches (17%) were responded to by interfering in their pace or space – either because the interference, from the mother's view, was justified by the child's well-being or not - than in Group A (25%) or C (35%). Therefore, these results support the hypothesis of more contingent appropriate maternal responses for infant social approach in the infants who developed secure attachment than in those who developed insecure attachment. However, this was not the case when the infant behavior was non-interactive, i.e. play. Indeed, the proportion of maternal sensitive vs. intrusive response was shown to be similar across the three attachment groups. Interestingly, regarding the promptness of maternal response the results showed effects, as expected, for infant play behavior but not for social approach. Thus, when Group-B infants focused on a toy or activity, their mothers proposed or commented something, respecting pace and space, more quickly than their counterparts' mothers did.

Our findings are congruent with the generally expected higher maternal appropriateness and promptness to the behavior of children who later developed secure attachment found in macro-analytical studies (Fearon & Belsky, 2016; De Wolff & van IJzendoorn, 1997). However, by considering contingency and the antecedent, the results of the present study showed a differential profile in terms of infant antecedent behavior. Maternal appropriateness was shown to be relevant regarding infant social approach while promptness was relevant as responding to infant attention to toys. Thus, when infants played, their mothers' profile of responses to them did not distinguish their subsequent quality of attachment. However, *how* promptly mothers responded to it did: they were more likely to be securely attached children. On the other hand, regarding infant social approach how promptly mothers responded did not relate to their child developing secure attachment but the quality of their response did; they responded with more sensitive vs. less intrusive behaviors.

Because the infant participants in this study showed no differences across the three groups, neither in their social approaches nor in their play behaviors, the results support the point made by Ainsworth (1997) that the differences are produced by the mother. She is the one who has to show her ability to gear her interaction to her infant's behavioral cues. The results can be interpreted in terms of the signals or behavioral cues involved in an infant social approach and in a non-interactive behavior like play or exploration. In the context of playing, the infant looking at the mother, or looking straight at what the mother shows or points to him or her, can be considered a strong signal to which mothers respond "promptly," so the differences among groups were in the *quality of the response*. However, when the infant explores and focuses on the toy the signal gives some scope for the mother to distract and only those mothers more attentive to the infant's action will respond promptly with a sensitive action or comment.

Additionally, it should be pointed out that in the free-play setting and with eight-old month infants, most infant social approaches are neutral, with some positives and very few negative, e.g. complaints addressed to the mothers or crying. Therefore, our findings showed that Maternal Sensitivity distinguishes subsequent attachment groups based mostly on non-distressed infant social signals. Although some interpretations of Maternal Sensitivity have argued that this is more relevant and visible in dealing with infant's distress that does not corresponded with Ainsworth's conceptualization (Ainsworth et al., 1978; Bretherton, 2013). Moreover, some studies have found that Maternal Sensitivity in face-to-face non-distressed situations and the same in distressed situations significantly correlate (Keller et al., 1996).

Dynamic of Temporal Organization of the Dyadic Interactive Process and Attachment

From the NDS perspective, the findings of this study provide important information regarding system dynamics and the temporal organization of these dyadic sequences as they change in time. Specifically, our findings focused on the infant-mother dyadic sequences changing over time in the all lag-state space and on the regions, and how this configures in attractors.

In the overall grid of lag-states, the multivariate combination of both the number of sequences changes from one to another and the number of consecutive events in each visit, were associated with the quality of attachment. In particular, Group C was distinguished from Groups B and A. However, there were no differences between Group B and A. This underlines the benefit of focusing on particular regions of the lag-state space that have a theoretical significance like those dyadic states that involve mother's intrusive responses. In our study, according to the infant antecedent there were two such regions: "Social Approach" and "Play."

Our expectations that they will discriminate the attachment groups was supported for the region involving infant's social approach responded with maternal intrusiveness, not for the one where play was the infant's antecedent behavior. Thus, the function including the rate of behavioral states and the rate of the visits to this particular region, correctly classified 78% of Group B, and 73% and 83% of Groups A and C respectively. These results underline that the importance of being, or not, intrusive for attachment purposes was related to infant's social approach, not when the infant is focused on toys where the relevant factor was promptness in the maternal sensitive response.

The results were congruent with the general findings of securely attached children, Group B receiving less intrusive behavior than their counterparts from insecure groups (Ainsworth et al., 1978). However, our findings provide more specific information. Not only for Group B was there less activity in this region, but, if there was any, it was more likely to involve positive affect. Interestingly, if mother responded with intrusiveness it was in a playful exchange in which both, infant and herself were positive. Likewise, not only was Group C the group with more activity, but this activity involved

intrusiveness with neutral valence. The infant social approach was also neutral. In contrast, Group A was shown to be in between Group B and C with regard to the activity in the region. Moreover, if there was any instance of an infant making a positive social approach to the mother and she responded with a neutral intrusive behavior, that instance was more likely to be found in a dyad classified as belonging to Group A.

In short, the B dyads not only showed less activity, as less events, and less moves across the different lag-states, but the behavioral states involving intrusiveness included mutual positive affection, which points to a playful engagement. This was not the case for any of group A or group C. This specific information can both guide intervention and refine new hypotheses in the study of the origins of security.

In NDS terms, although each dyad (system) potentially can be in any of the behavioral states (sequences infant-mother), only a few of these sequences tend to occur and recur. Therefore, all the possible specific behavioral states for the dyads in our study, i.e. the content, can be analyzed in terms of the structure, attractors, that limits the content that occurs and in what way (Hollenstein, 2013). It was expected that Group B would show a higher proportion of dyads with coexisting attractors or multi-stability; this structure shows the variability of the system, because more attractors mean that the dyadic behavior of the system is more variable, moving in-out of the attractor on the state space. Moreover, also the content of the attractors was examined and their quality and relative strength was analyzed in relation to the grouping factor of attachment.

Regarding number of attractors, results showed differences among the groups. As expected, there were more dyads from Group B showing two coexisting attractors (67%) few of those in Group A (36%) and one in Group C (17%). However, these results did not reach statistical significance. Therefore, conclusions regarding Group B showing more multi-stability as an indicator of variability in the system (Hollenstein, 2013) should be taken very cautiously and need to be replicated. The value of these results lies in suggesting new hypotheses for future studies.

Considering the specific behavioral sequences that became attractors for the dyadic trajectories, the most common sequences involved the mother sensitive response to both child's non interactive behavior, i.e. play (JS) and to infant social approach, neutral (AS). While a similar number of dyads across the three attachment groups had JS that was not the case with AS attractor. Group B showed significantly more dyads with AS attractor (78%) than Group C (17%). Moreover, in B-dyads the two attractors, involving infant interactive and non-interactive behaviors, showed similar strength in terms of return time. For the A-dyads, one attractor was significantly stronger than the other, that is dyads were quicker to return to the attractor with infant's non-interactive behavior, JS, than to AS. And for C dyads all but one had only one attractor, so most of them were not exposed to content by possible strength differences.

Taken together, the results regarding attractors showed that certain children interacting with their mothers in free-play besides tending, recurrently,

to stay in the JS cell, they also have another favorite cell which involves their social approaches to their mothers. Moreover, they move from one to another with similar return time. In our study there were more of these children in Group B, some in Group A, but they returned quicker to JS, and only one in Group C. One possible explanation for the lack of statistically significant results for the number of attractors could be the sample size. However, it could also be argued that another possibility may be that self-organizing process follow a different pace for each group of dyads. Therefore, we may find it difficult in one observation to capture the point in which the distribution shows more distinct relation with the grouping factor. Following this rationale, children who develop secure attachment would be more advanced than their counterparts, by showing moving in and out of two attractors and experiencing more variability between a favorite state involving their social approaches and another in which they pay attention to the objects. However, it could be hypothesized that eventually dyads from Group A and Group C will reach this point, and in doing so the "delay" would be a relevant factor in their socio-emotional development. This hypothesis would require repeated observations at different ages. This would allow the study of variability and self-organization within the session and between sessions which could shed light on the interactive process of dyads and the origin of security.

An Illustrative Case

We introduce John, a "prototypical" infant from our securely attached group with the purpose of meaningfully integrating the findings of this study that refer to the experience of the infant. John, was 8 months old. What did he experience in relating with his mother when they had a few minutes to play and there were some toys at their reach? When he looked, verbally or non-verbally, at his mother, his mother responded with a comment or a gesture that respected his pace and space on about 8 out of 10 times. It was sensitive. The few times that she responded interferingly with his pace or space, half of the instances were to change his position or roll up his sleeve, and the other half were mostly playful interferences. When he became interested in toys and exploration, his mother was attentive and reacted promptly by making a comment or proposing something, again sensitively respecting his pace and space.

John and his mother's dance of contingencies (behavioral sequences), showed a particular combination in terms of the overall amount of them, the interchanges that took place before moving to a different sequence, and the moves from one to another. This particular combination was clearly different from the children of group C. Moreover, regarding those behavioral states involving his mother responding with interference to John's social approach, the combination of their frequency with the visits to them, was very likely to distinguish him from the children in the other groups, A or C, because the interferences were fewer in number, more playful and John engaged with them.

Finally, John and his mother spent more time in their two "favorite" states: the one involving his play that his mother responded to promptly with

sensitive attention and the other involving his social overtures to which mother responded to sensitively as well. Therefore, they have some variability, while fewer of his counterparts had that experience, some of whom were children from Group A, and only one from Group C; the rest had only one "favorite" place where they spent most of their time.

The case example illustrates the multidimensional aspects and facets of Maternal Sensitivity experienced by the developing mind of the infant. That experience takes place in real time by which the infant develops on-going expectations regarding the contingencies between their behavior and their caregiver's reactions (Bigelow & DeCoste, 2003; Moore et al., 2009). Those are procedurally organized expectancies of actual experiences of mother's accessibility and responsiveness. Therefore, the infant's experience of receiving contingent responses is the basis of their internal working model for attachment (Beebe & Steel, 2013; Gergely, 2004). We believe that this sort of kaleidoscopic experience of Maternal Sensitivity requires that researchers take a more flexible approach that combines different strategies. In all of them, however, the temporal dimension of the interactive process needs to be considered. In this context, NDS principles play an important role in the study of the patterning of mother–infant interaction, which is central to infant social-emotional development.

Limitations, Strengths and Future Directions

This study presents some limitations. The main one was the sample size because studying the origins of attachment requires following a large number of dyads in the year before the children can be assessed using the Strange Situation Procedure. Additionally, given that there is already available knowledge in the field that can be used in an intervention, not to provide assistance to dyads who show particular dysfunctional interactive patterns presents ethical problems. Therefore, our dyads come from a program designed to support and assist all parents with their infants but who missed their visits due to incidental factors. Thus, they did not receive interventions about their interaction. It is a long process because the sample comes from several hundred dyads, over a number of years. Moreover, to select children whose attachment showed no D traits has restricted the final number and has also given groups with unequal sizes, which can be another limitation to generalizing these results. Obviously, future studies need to replicate these findings and, if possible, use a greater sample size.

However, there are some strengths. The quality of the sample of this study is one of them; the selection of children with organized attachment and no D behaviors or traits was done with the assistance of an internationally recognized independent expert. Another strength is the instrument used to analyze infant-mother interactive processes. The CITMI-R coding system used in a free-play setting which, with four minutes observation, has been shown to capture differences among dyads whose children develop different attachments. Moreover, the study shows the complementarity of different levels of analysis,

considering the temporal dimension to examine the Maternal Sensitivity construct. Finally, SSG methodology to detect antecedents of organized attachment moves up the field of early interaction and attachment into the level of analyzing temporal organization of the dyadic interactive processes using the NDS perspective.

Future research developments point to disentangling the aspects of the precursors of organized vs. disorganized attachment. Some light could be shone on this by using designs that include differentiated groups of ABC attachment with and without D traits, and children classified as Disorganized with their alternate "best-fitting" (secondary) organized category like "D/avoidant." Likewise, future studies with serial data of repeated observations and a bigger sample, could analyze aspects of intra-individual variability that could be related to attachment quality.

The findings of our study provided a more specific picture of infant-mother interactive processes that link with the development of organized attachment, secure and insecure. This picture can assist researchers to develop more specific hypotheses about the origins of security. Moreover, understanding the emergence of attachment insecurity sets out the bases for early detection and intervention due to the important implications of attachment insecurity for child development and adaptation that endures in working models and ongoing intimate relationship patterns. Therefore, in the context of health promotion, this can assist professionals in their work.

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