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Exploring Spontaneous Imitation in Infancy: A Three Generation Inter-Familial Study

Theano Kokkinaki*[a], Elena Vitalaki[b]

[a] Department of Psychology, University of Crete, Rethymnon, Greece. **[b]** Department of Social and Philosophical Studies, University of Crete, Rethymnon, Greece.

Abstract

With the aim to advance our understanding regarding the role of the extended family interactional context for early mother-infant communication, we compared spontaneous early imitative exchanges in dyadic interactions between mothers and infants (Group 1, *N* = 26) who had no frequent contact with maternal grandmothers, to imitations in two familial subgroups (Group 2, *N* = 48): (a) dyadic interactions of infants with their mothers, and (b) with their grandmothers–persons who had frequent contact with the infant. Spontaneous dyadic interactions of infants with their mothers and grandmothers were video-recorded at home from the 2nd to the 10th month of their life. Both comparisons provided evidence of similar frequency of imitative exchanges and developmental trajectories of infant imitations, but also differences in the structure of imitation, the kinds of imitated behaviors and the temporal patterns of imitative components. In the frame of the theory of Innate Intersubjectivity, we assume that differential early family interaction may be related to variations in three fundamental dimensions of infant-significant other communication: "kinematics" (temporal patterns), "physiognomics" (spatial patterns or forms) and "energetics" (force or effort). These variations may affect the child's ability for regulation and negotiation of interpersonal challenges within and outside the family context.

Keywords: imitation, infancy, grandmothers, three generation, temporal patterns, spatial patterns, intensity

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*Corresponding author at: University of Crete, Department of Psychology, 74 100 Rethymnon – Gallos, Crete – Greece. E-mail: kokkinaki@uoc.gr

Introduction

The aim of this study was to compare spontaneous early imitative exchanges in dyadic interactions between mothers and infants who had no frequent contact with maternal grandmothers, to imitations in two familial subgroups: (a) dyadic interactions of infants with their mothers, and (b) with their grandmothers–persons who had frequent contact with them. This study may advance our understanding of the role of the extended family interactional context on early mother-infant communication and, in turn, provide a window onto the child's ability to manage future meaningful social interactions.

Most research examining the grandmother-grandchild relationship focuses on high-risk, multigenerational adolescent-mother and maternal grandmother families (Oberlander, Black, & Starr, 2007). There is a surprisingly little research on the way in which grandmothers' involvement is related to the child socio-emotional development in less-risky contexts. The limited number of three generation familial studies focuses on 1- to 4-year old grandchildren and examines the relationship between grandmothers' involvement and infant attachment behavior (Myers, Jarvis, & Creasey, 1987), grandchildren's social adjustment (Barnett, Scaramella, Neppl, Ontai, & Conger, 2010), anger

(Brook, Tseng, Whiteman, & Cohen, 1998), independence and adaptive responding (Tomlin & Passman, 1989). Although the value of these studies can in no way be denied or underestimated, it is felt that they lack the systematic investigation of interactional dynamics of inter-generational relations in the course of infancy.

In the existing literature, agreements and disagreements on basic aspects of imitative phenomena in dyadic mother-infant (Kokkinaki, 1998; Kokkinaki & Kugiumutzakis, 2000; Kugiumutzakis, 1993; Moran, Krupka, Tutton, & Symons, 1987; Papousek & Papousek, 1989; Pawlby, 1977; Trevarthen, 1977; Uzgiris, 1984) and grandmother-infant interaction (Pratikaki, 2009; Pratikaki, Germanakis, & Kokkinaki, 2011) come mainly from non-comparative studies since there are only two three-generation familial studies available (Kokkinaki & Vitalaki, 2013; Markodimitraki, 2003). These studies provide evidence that there is an agreement on: a) the non-linear developmental trajectory of imitation, and b) the linguistic nature of vocal imitation (vowel imitations predominated over consonant and vowel-consonant combinations).

Nevertheless, there is no consensus in the literature on the following:

- the frequency of imitation: whether the mean number of imitations is high (2.53-6.02 imitations in 7-minute interaction), as in mother-infant interaction (Kokkinaki, 1998; Kokkinaki & Kugiumutzakis, 2000; Kugiumutzakis, 1993; Pawlby, 1977), or relatively low (1.3-3.7 imitations in 5 to 7 minute interactions), as in grandmother-infant interaction (Markodimitraki, 2003; Pratikaki, 2009; Vitalaki, 2002). Alternatively, the mean number of imitations does not differ in interactions between infants and their mothers and grandmothers (3 imitations in 10-minute interactions) (Vitalaki, 2002),
- the structure of imitation: Imitation occurs in turn-takings and co-actions, with no or rare occurrence of multiple exchanges (Markodimitraki, 2003), or turn-takings and coactions predominate over multiple exchanges (Pratikaki, 2009). Alternatively, multiple sequences with turn-taking(s) and co-action(s) and simple co-actions were more frequent than the other types of imitative structures (Vitalaki, 2002).
- The direction of imitation: mothers and grandmothers imitated their infants and infant grandchildren, respectively, more than vice versa (Markodimitraki, 2003; Pawlby, 1977; Pratikaki, 2009; Vitalaki, 2002), or maternal and infant vocal imitations were equally frequent (Papousek & Papousek, 1989),
- the kinds of imitated behaviors: vocal imitations predominated over the remaining categories (Kokkinaki, 1998; Markodimitraki, 2003; Pawlby, 1977; Pratikaki, 2009; Uzgiris, 1984), or body movement imitation occurred more frequently-to a non-statistically significant extent-in grandmother-infant girl interaction (Markodimitraki, 2003), and
- the temporal patterns of imitative sequence: differences have been evidenced in the durations of imitation sequence in both mother- and grandmother-infant imitation (Kokkinaki, 1998; Kokkinaki & Kugiumutzakis, 2000; Kugiumutzakis, 1993; Markodimitraki, 2003; Pawlby, 1977; Pratikaki, 2009; Vitalaki, 2002).

In this exploratory study, the general expectation was that there would be differences in the basic aspects of imitative exchanges between interactions of mothers and infants who had no frequent contact with their grandmothers, and two intra-familial subgroups: (a) interactions of infants with their mothers, and (b) interactions of the same infants with their grandmothers-persons who had frequent contact with the infant grandchild. As no studies truly similar to this one exist, our hypotheses were speculative rather than definitive. This study expands a three generation, intra-familial, longitudinal and naturalistic investigation on spontaneous imitation in dyadic interactions between infants and their mothers and grandmothers (Kokkinaki & Vitalaki, 2013) and adds new analyses.

One of the more prominent theories of imitation is that by Meltzoff who considers imitation to be a process that is intentional, goal corrected and mediated by memory. During the course of this process, the infant has the capacity to detect correspondences between his own actions and those of a model through two kinds of available information: temporal contingency (infants recognize that another moves when they move) and structural congruence

(infants recognize that another moves in the same manner as they do) (Meltzoff, 2007; Meltzoff & Moore, 1992, 1998). The infant encodes the visual–spatial–temporal events of human actions of self and other in a non-modality-specific representational code (Meltzoff, 2007). At the core of Meltzoff's theory of the origins of intersubjectivity and representation, the other is accessible to the self through cross modal correspondences. The recognition of self-other equivalences is the starting point for social cognition-a precondition for infant development, not the outcome of it (Meltzoff, 2007; Meltzoff & Brooks, 2007).

The theoretical consideration that the neonate brain senses corresponding movements and expression in a human conversational partner through temporal and morphological markers is very similar to that of Colwyn Trevarthen. This study has been carried out within the frame of the Theory of Innate Intersubjectivity (Trevarthen, 1993), according to which imitation has a dynamic intersubjective regulatory function. Imitation constitutes the process in which mental activity-including motives and emotions-is transferred between minds but the message it conveys changes according to age-related developments of infant's motives (Trevarthen, Kokkinaki, & Fiamenghi, 1999). Imitative intersubjective encounters with infants reveal coordination within- and between-subjects in three essential dimensions of communication that motivate learning in a human community: "kinematics" (the temporal patterns of movements), "physiognomics" (changes in the shape of the body, organizing postural, gestural, facial or vocal settings in distinct categories related to the subject's changing interest and purposes) and "energetics" (variations in the intensity, force or power of actions) (Trevarthen, 1986).

Both Meltzoff and Trevarthen attempt to conceptualize the origins of a theory of mind in infancy. For each, mind begins with a shared mind, a highly pre-symbolic representational intelligence and the central question is, for both, how can an infant sense the state of the other? Both theories posit that the motivated and intentional infant's perception of correspondence is the central mechanism in the creation of intersubjectivity (Beebe, Sorter, Rustin, & Knoblauch, 2003). Two points of difference stand out: the definition of correspondence/matching and the theory of mind underlying infant intersubjectivity. Regarding the first point of difference, for Meltzoff, the definition of correspondence rests on form, while for Trevarthen, correspondence is defined by behavioral similarities in timing, form and intensity. Despite the fact that Meltzoff acknowledges the importance of parent-infant imitation games, he studies the behavior of infants within an experiment, one-person view, and his concept of correspondence is more static than Trevarthen's who studies face-to-face two way communication. Trevarthen construes the dyad to be the unit of study and he operates within a mutual regulation model of communication, in which each partner affects the other, in the sense that each partner is predictable to the other, moment-by-moment. Regarding the different theories of mind, for Meltzoff, the origin of mind begins at birth with the perception "You are like me". The key mechanism is the perception and production of similarity. Trevarthen sees the origin of mind in the interactive process itself. Patterns of movement, transferred from subject to subject through form, timing and intensity, permit the intercoordination of inner psychological states (Beebe et al., 2003). The recent discovery of "mirror neurons" (Pally, 1999; Rizzolatti, Camarda, Gallese, & Fogassi, 1995, as cited in Beebe et al., 2003) seems to validate key ideas of these two theorists, long after they had the insight that infants appreciate correspondences between their own actions and those of the partners. The discovery of mirror neurons and our understanding of how the correspondences, described by Meltzoff and Trevarthen, may work at the neural level is further extended by the recent work of Saby, Marshall, and Meltzoff (2012). Saby and colleagues (2012) employed a socially interactive protocol and recorded Electroencephalographic (EEG) signals taken from 14 -month-old infants while they were observing the experimenter's actions that either matched or lacked the same imitative connection to the infant's own actions-while still being temporally contingent on the infant's act. Desynchronization (i.e. a decrease in band power relative to the baseline) of the EEG mu rhythm (an alpha-range EEG oscillation that is most salient over central electrode

sites) was greater when infants observed an action that matched their own most recently executed action. This effect was stronger when the infant had just carried out the same action than when he or she had just carried out a different action. This is consistent with recent ideas about the predictive processes activated by temporal patterns of brain activity during action observation.

Given that imitation constitutes an index of intersubjectivity (Pratikaki, 2009), systematic comparison of spontaneous early imitative exchanges in dyadic interactions of mothers with their infants (who had no frequent contact with maternal grandmothers) to imitations in two familial subgroups (dyadic interactions of infants with their mothers and their grandmothers-who had frequent contact with their infant grandchildren) in a Greek, Cretan sample, is important because:

- surprisingly little research has looked into the ways in which grandmothers and infant grandchildren interact or their importance in each others' lives (Myers et al., 1987). This is possibly because, theoretically, under optimal childrearing conditions, grandmothers' involvement may provide a nice addition to family life, but their roles are redundant to parental roles (Lavers & Sonuga-Burke, 1997),
- grandmother-grandchild relationships serve a crucial function in the well-being of all generations. On the one hand, emotional attachment to one's grandmother is a fundamental and unique component in a child's development. With that attachment comes the experience of being loved, accepted, a sense of security and warmth, a sense of self through their interaction, an historical sense of self, and the gift of a role model for one's future aging (Barranti, 1985; Waldrop, Weber, Herald, Pruett, Cooper, & Juozapavicius, 1999). On the other hand, the grandmother's involvement in the grandchild's care represents a very intense psychological experience, related to strong social and personal expectations as well as involving profound modifications in her self- image as an aging person. Giving and receiving affection from younger generations and the process of sharing life experiences seems to increase the self-esteem of the grandmothers (Gattai & Musatti, 1999), and helps them maintain internal continuity while creating a sense of integrity and purpose in life-a key element in preserving an internal balance needed for successful aging (Atchley, 1989, 1992, as cited in Waldrop et al., 1999). While caring for the grandchild, the grandmother accepts her children's parenthood and re-establishes links with her own children (Gattai & Musatti, 1999),
- research in communication and aging is only just beginning to take into account the fact that intergenerational communication does not occur in a relational vacuum (Harwood, 2000b). The grandparent-grandchild relationship may be a place in which future intergenerational competencies are learned. Individuals (old and young) who are able to negotiate a successful intergenerational relationship within the family may stand a better chance of doing the same elsewhere (Kornhaber & Woodward, 1985, as cited in Harwood, 2000a). Recent research, outside the grandparenting context, suggests that extended contact of this kind may be particularly influential in intensifying interpersonal intimacy, given that both parties (grandchildren and grandmothers) may experience an intergenerational relationship that extends over a long period of time (Harwood, 2000a), and
- Greece constitutes one of the European countries that rely considerably on grandparent care (Hank & Buber, 2007). Despite Crete's long history as part of modern Greece, Cretans conceive their communities as a kind of a small state, thus sustaining a long tradition of defiantly independent ways of life. This strong sense of identity associated with physical location has obvious psychological and emotional consequences on individuals and on the community as a whole. Besides strong emotional attachment to place, that fosters a feeling of belonging and a sense of sharing a community (Terkenli, Bellas, & Jenkins, 2007), the maintenance of strong and long family ties create mutual trust and understanding with special emphasis on intergeneration continuation. On this basis, we believe that exploration of the grandparent-infant grandchild communication in a Cretan context would make an important contribution to the cross-cultural literature on grandparenting. This investigation would give researchers a better understanding of the impact of the intergenerational relationship on individual, family and society well-being in a context that emphasizes family obligations and intergenerational exchange (Du, 2007; Szinovacz, 1998; van Willigen & Lewis, 2006, as cited in Lou & Chi, 2012).

Method

Participants

Seventy four Greek, Cretan, middle-class subjects (*N* = 74, 29 infants, 29 mothers and 16 grandmothers), distributed in two Groups, took part in this study. Group 1 (*N* = 26) consisted of thirteen mother-infant pairs. Group 2 (*N* = 48) consisted of sixteen mother-infant and sixteen maternal grandmother-infant pairs. All infants (Group 1: 8 girls and 5 boys, Group 2: 7 girls and 9 boys) were full-term and healthy and they were delivered at a maternity hospital in Rethymnon, Crete. Pregnancy, duration of labour, and perinatal factors were within normal limits. Written records and regular discussions with the mothers and the pediatricians, concerning the infants' development, confirmed that all the infants were developing according to typical developmental curves, with no identifiable developmental handicaps. All mothers were married to the infants' fathers.

Participants in Group 1: The infants' mean birth weight was 3,475 gr (range = 2,400-3,800) and the mean birth weight height was 50 cm (range = 48-55). At the beginning of the study, the mothers' mean age was 26 years (range = 18-34 years). Thirty one percent of the mothers had 12 years of education and the remaining had 16 years of education (seven had a University degree and two had a degree from a Technological Education Institute). All maternal grandmothers lived either outside Crete, in villages of the province of Rethymnon or in the greater area surrounding the town of Rethymnon (at a distance exceeding a 5 to 10 km radius of the infants' and adult children's residence). Maternal grandmothers interacted with their infant grandchildren once to 2 times per 15 days. Paternal grandmothers who were alive (*N* = 10), lived in Rethymnon and interacted with their grandchildren once to 4 times a month.

Participants in Group 2: The infants' mean birth weight was 3,200 gr (range = 2,400-3,800) and the mean birth weight height was 50 cm (range = 48-55). At the beginning of the study, the mothers' mean age was 28 years (range = 22-35 years). Sixty two percent of the mothers had 12 years of education and the remaining had 16 years of education (four had a University degree and two had a degree from a Technological Education Institute). The maternal grandmothers' mean age was 62 years (range = 50-75 years). Fifty percent of the grandmothers had six years of education, forty four percent had 12 years of education and one grandmother had 16 years of education. Sixty nine percent of the grandmothers were housewives, eighteen percent were housewives with rural occupation and the remaining were occupied in a family business. All maternal grandmothers had daily contact with their grandchildren and lived either in the same building, or within a 5-kilometer radius of the infants' and adult children's residence. In interviewing adult mother-daughter pairs, we noted the closeness of their relationship. Of all paternal grandmothers who were alive, twelve lived in Rethymnon and interacted with their grandchildren once to 4 times a month and the remaining four lived in villages within the province of Rethymnon at a distance exceeding 25 kilometers (maternal grandmothers will be referred to from here on as "grandmothers").

Procedure

The mothers and grandmothers were approached after birth in the maternity clinic or at home through the obstetricians and pediatricians who offered the researchers access to birth and pediatric records. After mothers and grandmothers agreed to participate in the study, an introductory discussion took place at the infants' homes. The first visit was arranged at a time when the infant was likely to be fed, relaxed and alert, and at a time usually amenable to social games (Kugiumutzakis, 1993). If the infant was unwell or became distressed, or the mothers felt that the visit should be postponed for some reason, or the grandmothers were taken ill, the visit was rescheduled to a later date soon thereafter.

Videorecordings were made at 15-day intervals, starting when the infant was 2 months old until she/he was 10 months old. The recording with each partner lasted 10 minutes. In Group 2, the recording with the first partner (mother/grandmother) was followed as soon as possible by the recording with the other partner so that a change in the infant's mood would be less likely. The order of videorecordings with the mother and the grandmother was counterbalanced, beginning in the course of the first visit, for 3 girls and 5 boys, with the mother and then with the grandmother; for the remaining infants (4 girls and 4 boys) the first videorecording was made with the grandmother and then with the mother. During the second visit, the order of interaction was switched, and this continued in the next visits.

Over the course of the study, 17 videorecordings were made for each infant with her/his mother and grandmother. In Group 1, a total of 221 videorecordings [13 infants x 17 visits], lasting 2.210 minutes of spontaneous interaction, were made for the entire sample. In Group 2, a total of 544 videorecordings [16 infants x 17 visits x 2 partners (mother/grandmother)], lasting 5.440 minutes of spontaneous interaction, were made for the entire sample; 272 (2720 minutes of interaction) with the mothers and 272 (2720 minutes of interaction) with the grandmothers. The instruction given to the mothers and grandmothers was: "Please, play as you normally do with your baby/infant grandchild". The recording took place in a room and a position chosen by the mothers/grandmothers, prohibiting any third-party intervention. At the end of the study, partners were given a short debriefing interview. None of the mothers/grandmothers was aware that imitation had been the focal point of interest in this study.

One point worth making is that when investigating imitation in infants, particularly young ones, it is critical that testing conditions be highly sensitive to the infant's state, e.g. infants do not imitate well when models are presented with mechanical regularity and insensitive insistence, as can be the case in "well-controlled" experiments that aim to reduce the factors that might be involved in triggering a matching response (Kugiumutzakis, 1993; Murray & Andrews, 2000). When infants are observed responding to caregivers with calm and affectionate mutual concern, they demonstrate active emotional initiative in a great variety of expressions, and they show communicative purpose (Trevarthen et al., 1999) (this study was conducted in accordance with all ethical standards for research, see Notes and Acknowledgements).

Coding

An imitative sequence was defined as a period from the moment that the model's expressive behavior (vocal, motor or a combination) started, until the completion of the imitator's last imitative behavior. Imitation was defined as an exchange in which one partner made a certain type of expressive behavior that had not been expressed by either partner in the immediately preceding 10 seconds, and in which the other partner reproduced this behavior within a 10-second interval and with no intervening expressive behaviors. The response period of 10 seconds has been judged to be adequate for imitation tests with infants (Heimann & Ullstadius, 1999; Kokkinaki, 1998; Kokkinaki & Kugiumutzakis, 2000).

In this study, the following aspects of imitation were analyzed:

- the frequency of imitation as an entire sequence across the age range of this study (2nd to 10th month after infants' birth),
- the structure of imitative sequences, which indicates the timing between the model's and the imitator's expressive behavior. Imitative sequences were categorized in three types: turn-taking, simple co-action and multiple exchange. In turn-taking, the completion of the model's expressive behavior and the beginning of the imitator's response are separated by a pause of no longer than 10 seconds. The number of pause(s) between each of the model's and the imitator's expressive behavior determined the simplicity or complexity

of the turn-taking. For instance, simple turn-taking was coded in the following example: [mother (model)-pause-infant (imitator)]. A simple co-action occurs when the beginning of the imitator's expressive behavior occurs before the completion of the model's expressive action. In instances in which this pattern was repeated successively more than once, the co-action was coded as multiple. When the imitative exchanges were complicated in a way that could not be categorized in either of the two basic types of imitative sequences, they were coded as multiple exchanges consisting of turn-taking(s) and co-action(s),

- the kind of imitated expressive act, which was classified within one of the following categories: vocal imitation (vowels, consonants, vowel-consonant combinations), non-speech sound imitation, facial expression imitation, imitation of hand movements and combinations of the above four categories [for the detailed definitions of the imitated expressive acts see Kokkinaki & Vitalaki (2012)],
- the direction of the imitative episode, which indicates who the initiator of the modeled behavior is and who gives the first imitative response (for example, the infant expresses a behavior and the mother imitates the infant), and
- the temporal patterns of simple turn-taking imitative exchanges, that is, the duration of model, pause, imitator response and the total sequence. We did not analyze the temporal patterns of co-actions and multiple exchanges due to their complexity which makes it difficult to determine who imitates who in a sequential order.

Inter-and intra-observer reliability measurements were calculated for the structure, the kinds, the direction and the durations of imitative sequences. To check intra-observer reliability, the second researcher (Elena Vitalaki) analyzed 100% of the recorded data and re-scored a random sample of 33% of the material after an interval of one month following the first coding session; agreement was assessed using Cohen's Kappa. Intra-observer reliability scores for all categories ranged from 0.73 to 0.91. The mean value of k for all categories was 0.81.

To check inter-observer reliability, an undergraduate student at the Department of Philosophical and Social Studies was trained in the micro-analysis of data and she scored a random sample of 15% of the material. "An agreement" was counted when the two observers recorded the same aspect of imitation [for example, the kind of imitation: vocal imitation (vowels, consonants, vowel-consonant combinations), non-speech sound imitation, facial expression imitation, imitation of hand movements and combinations of the above four categories] at times that either overlap or are separated by no more than two seconds. "A disagreement" was counted when: a) one observer recorded an aspect of imitation and the other didn't (in the same example, one observer recorded a vocal imitation and the other didn't), b) one observer recorded a category of a certain aspect of imitation (e.g. vocal imitation) and the other recorded another category of this aspect (e.g. a non-speech sound imitation), or c) when both observers agreed that a certain category of imitation was to be scored (e.g. vocal imitation) but disagreed on the subcategory of it (e.g. one observer scored a vowel sound imitation while the other scored a vowel-consonant combination). Inter-observer reliability between the researcher's first analysis and the student's analysis ranged between 0.68 and 0.84. The mean value of k for all categories was 0.74.

The difficulty of establishing high inter-observer reliability, when a complicated coding system is used, should be noted. The increased task demands on the rater and the multiple messages of a complex interaction itself are recognized as two factors that contribute to the difficulty of establishing high inter-observer reliability (Bakeman & Gottman, 1986). In particular reference to sequential analysis, the establishment of inter-observer reliability is even more difficult due to the fact that any disagreement can result in lack of synchrony and thus prevent subsequent matching of comparisons (Hollenbeck, 1978). Given these constraints, it is felt that the inter-observer reliability scores given above are satisfactory. Fleiss (1981) characterizes kappas of 0.60 to 0.75 as good and over 0.75 as excellent.

Statistical Analysis

For the statistical analysis, Loglinear Models (Everitt, 1977) were used to determine possible relationships between categorical variables, and Chi-square test was used to analyze significant relationships. A Loglinear Model is a linear model for the logarithms of level combination frequencies of the categorical variables under investigation. The term linear means that the expected values of observations are given by a linear combination of a number of parameters. A Loglinear Model can be useful in determining simple or interaction effects between categorical variables (Everitt, 1977). The z-values, that appear in the Loglinear models, are used for testing the significance of differences between model coefficients. When Loglinear Model Analysis gave a significant relationship between categorical variables, Chi-square tests were used in order to analyze this relationship since one use of the Chi-square test deals with the situation in which we have two variables and want to determine whether these variables are independent of one another (Howell, 1987). For each analysis, the p-value that represents the greatest z-value appearing in the Loglinear Model and the Chi-square test value will be presented. This experiment, by its nature, generated data with relatively strong dependencies between them since repeated observations are obtained on a relatively small number of individuals. These longitudinal dependencies were not taken into account in the analysis because of their complexity, and this would also tend to increase the number of significant results. For this reason, the significance level for Chi-square tests and Loglinear Models was set at 1%, as a safeguard against false rejections of the null hypothesis. In cases where proportions of two-outcome analyses were assessed (i.e. direction of imitation), Binomial tests were used to test equality of outcomes. The significance level for the Binomial test was set at 5%. All analyses were performed using the SPSS statistical package (Version 17.0, 2008).

Results

Frequency of Imitation

The frequency of imitative sequences was not found to differ between: a) mother-infant pairs of Group 1 (N = 583, 3.7 imitations in 10-minute interaction) and Group 2 (N = 561, 3.0 imitations in 10 minute interaction) (p = .55, two-tailed Binomial test), and b) mother-infant pairs of Group 1 and grandmother-infant pairs of Group 2 (N = 597, 3.1 in 10-minute interaction) (p = .68, two-tailed Binomial test).

In Group 1, the total number of imitative sequences in each of the 13 pairs (across the 8 months of the study) ranged from 20 to 106, while the number of imitative sequences for each age level ranged from 12 to 63. In Group 2, the total number of imitative sequences in each of the 16 mother-infant and grandmother-infant pairs ranged from 17-76 and 13-80, respectively, while the number of imitative sequences for each age level ranged from 12 to 70 and 9 to 60, respectively.

Structure of Imitative Sequences

Loglinear Model and Chi-square test analysis showed a significant difference in the structure of imitative sequences between: (a) mother-infant pairs of Group 1 and mother-infant pairs of Group 2 [Loglinear Model (z = -5.23, p < 0.0001), Chi-square analysis (X^2 = 37.96, df = 3, p < 0.0001)]. This is due to the high frequency of turn-taking imitative sequences in the mother-infant pairs of Group 1 compared to the mother-infant pairs of Group 2 (40% and 23%, respectively) and the low frequency of simple co-actions (26% and 35%, respectively) and multiple exchanges with turn-takings and co-actions (28% and 36%, respectively), and (b) mother-infant pairs of Group 1 and grandmother-infant pairs of Group 2 [Loglinear Models (z = -4.78, p < 0.0001), Chi-square analysis (X^2 = 38.03, df = 3, p < 0.0001)]. Similarly to difference (a), this is due to the high frequency of turn-takings in the mother-infant pairs of Group 1 compared to the grandmother-infant pairs of Group 2 (40% and 23%, respectively)

and the low frequency of simple co-actions (26% and 35%, respectively) and multiple exchanges (28% and 34%, respectively).

Kinds of Imitated behaviors

Statistical analysis showed significant differences in the kinds of imitated behaviors between the mother-infant pairs of Group 1 and the mother and grandmother-infant pairs of Group 2. In particular, significant differences were found between:

- the mother-infant interactions of Group 1 and Group 2 [Loglinear Model ($z = 4.21$, $p < 0.01$), Chi-square analysis ($X^2 = 46.97$, $df = 4$, $p < 0.0001$)]. This difference is due to the evidence that vocal imitation and non-speech sound imitation were more frequent in mother-infant pairs of Group 1, compared to mother-infant pairs of Group 2 [vocal imitation (80% and 75%, respectively), non-speech sound imitation (8% and 4%, respectively)], while hand movement imitations were more frequent in the mother-infant interactions of Group 2 compared to Group 1 (12% and 3%, respectively), and
- the mother-infant interactions of Group 1 and grandmother-infant interactions of Group 2 [Loglinear Model ($z = 5.38$, $p < 0.0001$), Chi-square analysis ($X^2 = 63.14$, $df = 4$, $p < 0.0001$)]. Similarly to (a), this is attributed to the evidence that vocal imitation and non-speech sound imitation were more frequent in the mother-infant interactions of Group 1, compared to the grandmother-infant pairs of Group 2 [vocal imitation (80% and 73%, respectively), non-speech sound imitation (8% and 5%, respectively)], while the reverse was found for hand movement imitation (3% and 15%)].

Direction of Imitative Sequences

Loglinear Model and Chi-square test analysis showed:

- a significant difference in the direction of imitative sequences between the mother-infant pairs of Groups 1 and 2 [Loglinear Model ($z = 4.85$, $p < 0.0001$), Chi-square analysis ($X^2 = 23.97$, $df = 1$, $p < 0.0001$)]. This difference is due to the high frequency of maternal imitations of infant behaviors in Group 1, compared to Group 2 [(460, 79%) and (371, 66%), respectively], or reversely, the low frequency of infant imitations of maternal behaviors in Group 1 (123, 21%), compared to Group 2 (190, 34%),
- a non-significant difference in the direction of imitative exchange in the mother-infant interactions of Group 1 (460, 79%) and the grandmother-infant interactions of Group 2 (419, 70%) [Loglinear Model ($z = 2.82$, $p = 0.08$), Chi-square analysis ($X^2 = 30.02$, $df = 1$, $p = 0.03$)].

Temporal Patterns of Imitative Sequences

The descriptive comparison of the temporal patterns of imitative sequences between the mother-infant pairs of Group 1 and the mother- and the grandmother-infant pairs of Group 2 provides evidence that:

- model duration was shorter in the mother-infant pairs of Group 1 (mean = 1.44 secs, *SD* = 1.10, min: 0.44 and max: 7.36) compared to the mother-infant (mean = 1.86 secs, *SD* = 1.78, min: 0.56 and max: 12.20) and grandmother-infant pairs (mean = 1.63 secs, *SD* = 1.57, min: 0.52 and max: 13.48) of Group 2,
- the mothers and infants of Group 1 waited longer (mean = 0.74 secs, *SD* = 1.03, min: 0.03 and max: 5.92) before they imitated each other, compared to the grandmothers and infants (mean = 0.54 secs, *SD* = 1.11, min: 0.03 and max: 8.84) and mothers and infants (mean = 0.62 secs, *SD* = 0.88, min: 0.03 and max: 6.00) of Group 2,
- the imitator's duration lasted almost the same in the mother-infant interactions of Group 1 (mean = 1.96 secs, *SD* = 2.04, min: 0.03 and max: 14.92) and the mother- and grandmother-infant interactions of Group 2 [mean = 1.99 secs (*SD* = 1.43, min: 0.48 and max: 6.52) and mean = 2.06 secs (*SD* = 1.59, min: 0.14 and max: 9.60), respectively], and
- the total duration of the imitative sequence was longer in the mother-infant interactions of Group 2 (mean = 5.62 secs, *SD* = 4.25, min: 1.32 and max: 29.48) compared to the mother-infant pairs of Group 1 (mean

= 5.38 secs, *SD* = 5.54, min: 1.16 and max: 51.76) and the grandmother-infant interactions of Group 2 (mean = 5.11 secs, *SD* = 4.28, min: 1.28 and max: 29.64).

Infant Age Effect on the Developmental Trajectory of Imitation

Statistical analysis showed a non-significant effect of infant's age on infant imitations in the mother-infant interactions of Group 1 [Loglinear Model ($z = 1.65$, $p = 0.1$), Chi-square analysis ($X^2 = 24.22$, $p = 0.08$)] and mother [Loglinear Model ($z = 1.24$, $p = 0.22$), Chi-square analysis ($X^2 = 14.59$, $p = 0.55$)] and grandmother-infant interactions of Group 2 [Loglinear Model ($z = 1.83$, $p = 0.06$), Chi-square analysis ($X^2 = 28.98$, $p = 0.02$)] (Kokkinaki & Vitalaki, 2013).

Descriptive comparisons provide evidence that the developmental trajectories of infant imitative behavior did not differ significantly between the mother-infant pairs of Groups 1 and 2 and the mother-infant pairs of Group 1 and grandmother-infant pairs of Group 2 across the age range of this study, although infant imitations in the mother-infant interactions of Group 2 showed a non-significant increasing trend at 9.5 months. Statistical analysis showed a non-significant effect of the infant's age on maternal imitations in Groups 1 [Loglinear Model ($z = 1.96$, $p = 0.04$), Chi-square analysis ($X^2 = 22.45$, $p = 0.12$)] and 2 [Loglinear Model ($z = 1.52$, $p = 0.12$), Chi-square analysis ($X^2 = 26.68$, $p = 0.04$)] while the infant's age was found to significantly affect the grandmothers' imitations [Loglinear Model ($z = 2.97$, $p = 0.002$), Chi-square analysis ($X^2 = 45.38$, $p = 0.0001$)] (Kokkinaki & Vitalaki, 2013). This effect is attributed to a significant increase in grandmothers' imitations after the 7th month of infants' life. This descriptive comparison provides evidence that the developmental trajectories of maternal imitative behavior did not differ significantly between mother-infant pairs of Groups 1 and 2 across the age range of this study (Figure 1).

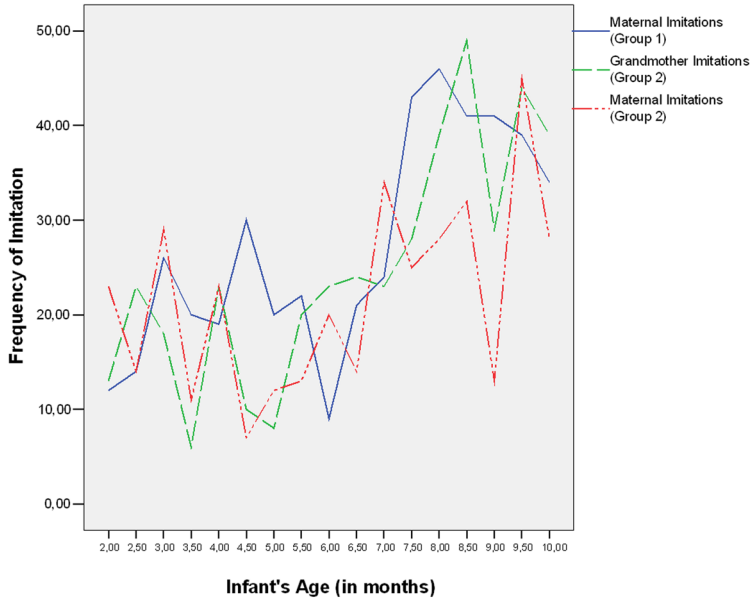

Figure 1. Developmental trajectories of maternal imitations of Group 1 and maternal and grandmother imitations of Group 2.

Discussion

With the aim to advance our understanding of the role of extended family interactional contexts on early mother-infant communication, we compared spontaneous early imitative exchanges in dyadic interactions between

mothers and their infants (Group 1) who had no frequent contact with maternal grandmothers, to imitations in two familial subgroups (Group 2): (a) dyadic interactions of infants with their mothers, and (b) with their grandmothers–persons who had frequent contact with the infant grandchild.

Both comparisons provided evidence suggesting similar frequency of imitative exchanges and developmental trajectories in infant imitations, while outlining differences in the structure of imitation, the kinds of imitated behaviors and the temporal patterns of imitative components. The direction of imitation was found to differ between mother-infant pairs in Groups 1 and 2 along with the developmental trajectories of maternal imitations in Group 1 and grandmothers' imitations in Group 2.

Imitation serves a dynamic intersubjective regulatory function, that is, it constitutes the process in which mental activity–including motives and emotions–is transferred between minds but the message it conveys changes according to age-related developments of infant's motives (Trevarthen et al., 1999). Similarity in the frequency of imitative exchanges and the developmental trajectories of infant imitations implies that the extent of direct intermotive attraction in interactions between infants and their significant others (mothers/grandmothers) does not differ, totally and longitudinally, according to early extended family interactions.

Imitative intersubjective encounters between infants and significant others reveal coordination in: "kinematics" (temporal patterns), "physiognomics" (spatial patterns or forms) and "energetics" (force or effort) (Kokkinaki, 1998). We assume that differences in the structure and direction of imitation, the kinds of imitated behaviors and the temporal patterns of imitative components provide evidence of variations in "kinematics", "physionomics" and "energetics" between the mother-infant pairs of Group 1 and the mother- and grandmother-infant pairs of Group 2. In particular, differences in the structure of imitation (according to the definition of it, see Coding section, The Structure of Imitative Sequences), along with variations in the temporal patterns of imitative components, presuppose that mothers, grandmothers and infants make different timing adjustments, to obtain inter-synchrony. The mother-infant pairs of Group 1, structured their imitative exchanges more frequently in turn-takings than co-actions and multiple exchanges, compared to the mother and grandmother-infant pairs of Group 2, in which imitations "unfolded" more frequently in multiple exchanges and co-actions, than in turn-takings. The alternating expressions and predictable timing features of the infant-adult turn-taking imitative exchanges indicates that: "…perhaps they have matching cycles of motivation leading to regular sequences of active expression (assertion) and attentive reception (apprehension)" (Trevarthen et al., 1999, p. 147). It seems that even in these assertion (model)–apprehension (imitator) cycles, the mothers, grandmothers and infants of Group 2 manifest behavioral expressions (model) and imitations longer in duration, although they seem to be more eager to imitate each other, as shown by the shorter pauses taken, compared to the mother-infant pairs of Group 1 (see Results, the section Temporal Patterns of Imitative Sequences). Frequent multiple exchanges of expressive behaviors (which presupposes patterns of synchronization and alternation) in both the mother and grandmother-infant pairs of Group 2 may imply that, through a systematic motivated negotiation, all partners work to make their timing finely adjusted in a mutually controlled and extended process (Trevarthen, 1988). Furthermore, the differences in the kinds of imitated behaviors between Groups 1 and 2 showed that vocal imitations were more frequent in the mother-infant pairs of Group 1, compared to the mother- and grandmother-infant pairs of Group 2. These differences may be integrated by the supposition that: "… voices, emerging from within moving human bodies, like all movements, *make time*..." and "vocal exchanges involves confluence of 'fluxes of inner time' " (Trevarthen & Gratier, 2005; Schutz, 1951, as cited in Gratier & Trevarthen, 2007, p. 170) in order to reinforce our assumption for variations in "kinematics" between the two Groups. Moreover, our hypothesis regarding the predictable timing features of the infant-adult

turn-taking imitative exchanges is further reinforced by the recent evidence that desynchronization of the infant's EEG mu rhythm was greater when the infant had just carried out the same action–during the 500-ms epoch preceding the experimenter's matching action than when he or she had just carried out a different action (Saby et al., 2012).

Despite the fact that, in this study, the coding of imitation did not include fine-grained measurements of muscle activity, variations in the kinds of imitated behaviors indirectly imply differences in "physiognomics", that is, adjustment of spatial patterns or forms of muscle activity between Groups 1 and 2. Different imitated behaviors between Groups 1 and 2 may show consistent differences in form according to which organs of display (facial, vocal or gestural) are transformed into shapes of expression in distinct categories related to the subject's changing interest and purposes (Trevarthen, 1986). This is further reinforced by:

- our informal observation that the significant increase of grandmothers' imitations after the 7th month may be attributed to the frequent use of playful expressive hand games (clapping) and conventional gestures (waving, pointing), in conjunction to
- the speculation that the non-linear developmental trajectory of imitation from the 2nd to the 10th month of infants' life might be due to periodic reorganizations in the infant's motivational system. These infant motivational reorganizations may lead either to corresponding motivational changes in grandmothers and/or to changes in significant others' perceptions of the infant's interests and emotions (Kokkinaki, 1998; Kugiumutzakis, 1993; Trevarthen, 2005). Vocal and non-speech sound imitations imply different adjustment of the spatial patterns between mothers, grandmothers and infants' facial muscle activities. This may be related to the supposition that: "The human facial communicative system is described as having ....1. A highly differentiated facial anatomy comprising a forward-facing, bony frame covered by skin in which is attached a bisymmetric set of muscle units that are differentially excitable..." (Trevarthen, 1985, p. 22), and that "...the discrete facial muscle actions visible in the adult can be identified and finely discriminated in newborns" (Oster & Ekman, 1978, as cited in Field, 1982, p. 284).

Differences in "energetics" are provided by the structure of imitation and the kinds of imitated behaviors. Based on the speculation that co-actions constitute: "…an index of the intensity of affective arousal, regardless of quality" (Beebe, 1982, p. 194), we assume that the frequent manifestation of simple co-actions, along with their systematic presence in multiple exchanges, in the mother and grandmother-infant pairs of Group 2 compared to the mother-infant pairs of Group 1, provide evidence of differences in "energetics" between Groups 1 and 2. The frequent expression of vocal imitations in Group 1, compared to Group 2, further reinforces our assumption. Infant vocal imitative efforts have the characteristics of effort vocalization. The behavior of infants during the emission of maternal sounds has been characterized by gradual localization of the sound, with head turning and eye widening, while the brows were held high–a movement which occurs in attention listening (Keller & Scholmerich, 1987; Rinn, 1984, as cited in Kugiumutzakis, 1993).

It has been assumed that human communication is regulated by an integrated system of equivalent expressions (Trevarthen, 1993). In connection to this, the difference in the direction of imitative exchanges between the mother-infant pairs in Groups 1 and 2 may reflect variations in the integrated system of equivalent expressions. In particular, in the context of the stable and systematic presence of a complementary caretaker (their own mother), the mothers of Group 2 may enrich their improvisation in interaction with their infants with more complementary "translations" of infants' expressions than imitations. The intrinsic relation to others that infants feel preverbally and this "felt connection" have a profound effect on infants' first interactions and interpretations of the social world and constitute the foundation for human communication and development (Meltzoff & Brooks, 2007). It may be that this interaction style provides evidence of the way in which past experiences and present interpret-

ations of these experiences influence current interactions (Cohler, 1982; Elder, Caspi, & Downey, 1986, as cited in Whitbeck, Hoyt, & Huck, 1993).

In sum, this study provided evidence that differential early family interaction histories may be related to variations in three fundamental dimensions of infant-significant other communication: "kinematics" (temporal patterns), "physiognomics" (spatial patterns or forms) and "energetics" (force or effort). These variations may affect the child's ability for regulation and negotiation of interpersonal challenges within and outside the family context.

Our conclusions are limited in a number of ways. These data describe the imitative exchanges in a restricted Cretan white and middle-class sample of grandmothers of close proximity to their grandchildren and adult children. Our observations are based on a relatively short time period with respect to the total interaction time spent between grandmothers and grandchildren. Generalizing these findings to other populations is limited because:

- grandparents in Greece are actively involved in and contribute to the family's well-being by socialising with grandchildren, helping with household chores and providing financial help (Svensson-Dianellou, Smith, & Mestheneos, 2010), and
- it may be that in Crete, the grandmaternal role represents a powerful psychological experience, full of emotional implications, and abounding in consequences for the relations between the grandmother and the other members of the family (Gattai & Musatti, 1999).
- mother-infant and grandmother-infant dyads of Group 2 were also homogeneous in terms of the positivity of the relationships. Unfortunately, grandmother-mother dyads who do not like each other or do not get along well are not the ones who volunteer to take part in a research study together (Myers et al., 1987),
- it would be remiss not to mention other qualitative and quantitative intervening factors that possibly had a different effect on the mother-infant interactions of Group 1 and the mother and grandmother-infant interactions of Group 2 such as: family relationship histories, individual styles and stages of grandmotherhood, the age of the grandmothers themselves, their educational level, the social status and the status of their health as well as their satisfaction with life (Krasnova, 2002; Whitbeck, Hoyt, & Huck, 1993). Hence, it is possible that we have uncovered variables that differentiate extremely satisfying relationships from those that are more neutral (Harwood, 2000b).

Despite these shortcomings, the present study adds to a growing body of literature that shows how the early extended family interactional context may set in motion different behavioral patterns that affect family members' (grandchildren's, mothers' and grandmothers') interaction styles to manage future meaningful social interactions throughout their lives. Additional research directed at the systematic analysis and comparison of interaction patterns between the first, the second, the third (to include great grandfathers, grandfathers and fathers, respectively) and fourth generation would help to further elucidate the nature of inter-generational relations in infancy. This assumption is integrated in Bråten (1991)'s evidence of "…gradual mutual approach and signs of similar gestures…" between an 8 – week-old infant grandchild interacting with her great grandmother "…with an age span of 94 years between them".

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About the Authors

Theano Kokkinaki received her PhD from the University of Edinburgh (1998) under the supervision of Professor Colwyn Treavarthen. She is an Assistant Professor of Developmental Psychology in the Department of Psychology, University of Crete (Greece). Her research interests concern the systematic study of interpersonal dynamics in infant-parent and grandparent interactions in several cultural contexts as well as twins interactions and triadic interactions between family members. She has 30 publications in Greek and international peer-reviewed journals and chapters in books in the field of infant development and intersubjective communication.

Elena Vitalaki is a Visiting Assisting Professor in the Department of Education at the University of Crete (2002-2012). Her current research emphasis focuses on School and Family Relationships and she has participated in projects concerning communication within the family and school settings. She has papers published in Oxford University Publications and in International and Greek scientific journals.