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Would you like to play together? Adults' attachment and the mirror game

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ABSTRACT
Why is it easy for some people to play together and difficult for others? In this interdisciplinary pilot study, we looked at dyadic interaction in motion as a paradigm to explore the expression of attachment in adulthood. We used a device that gives simple, quantitative and automated indicators for the quality of interaction while playing the mirror game. Forty-seven participants played the mirror game with the same gender-matched expert players. In addition, participants were interviewed on the Adult Attachment Interview to assess their quality of attachment. Using high resolution kinematic measures, we found that secure attachment was correlated with high complexity of the game and low synchrony compared to insecure attachment. The findings suggest that security of attachment is related to a more exploratory and less rigid game than insecure-dismissing attachment. These preliminary findings imply that high resolution analysis of simple movement interaction could carry information about attachment behavior.

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Adult Attachment Interview; AAI; adults' interaction; exploration; mirror game

For some people, interacting in motion is easy and enjoyable. For others, the thought of meeting another person and playing together is threatening and unpleasant. Why is it easy for some and difficult for others? In this study, we looked at dyadic interaction in motion as a paradigm to explore the expression of attachment in adulthood.

Attachment theory is one of the most influential theories on human relationship across the lifespan (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969/1982; Shaver, Belsky, & Brennan, 2000). According to attachment theory, human beings are endowed with an "attachment behavioral system" that evolved to assure a person's – especially a young child's – proximity to a caregiver who provides assistance and protection in times of need (Shaver et al., 2000) and to provide a "secure base from which to explore the world" (Ainsworth, 1963). Thus, attachment behavior conveys a social system in which confidence in the other's availability and responsiveness organizes exploratory and contact-seeking behavior (Crowell et al., 2002).

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Supplemental data for this article can be accessed here.

Hence, from an attachment perspective, there are two important systems of behavior that are highly related to each other: the attachment system and the exploratory system. One seeks protection and proximity, and the other seeks to learn about the environment through exploration. In the present study, we hypothesized that the interplay between these two systems (Ainsworth, Bell, & Stayton, 1971) is expressed during dyadic interaction of two individuals mirroring each other.

One of the central assumptions of attachment theory is that individuals differ in their quality of attachment, varying in terms of secure vs. insecure attachment. These differences are formed in the context of the child–caregiver relationship and facilitate the development and maintenance of a mental representation of self and other known as the *Internal Working Model*. The Internal Working Model organizes thoughts, feelings and behavior that influence adult relationships (Bowlby, 1979; Hazan & Shaver, 1987; Pietromonaco & Barrett, 2000).

The vast majority of studies of attachment have been in the context of children and their caregivers, but the theory was explicitly formulated as a lifespan theory (Ainsworth, 1989; Bowlby, 1979) and, in the last decades, focus has been given to study attachment also in adulthood. Whereas traditional approaches to assessment of attachment in childhood depended heavily on observation of non-verbal behavior, the studies of attachment in adulthood focused mainly on mental representation, interviews, and self-report (Crowell, Fraley, & Shaver, 1999; Shaver et al., 2000). Thus, there is a lack of experimental paradigms to study attachment in adults based on observation of non-verbal interactions.

To address this, we offer a new paradigm to the study of attachment in adulthood, based on the behavior of adults during non-verbal interaction while mirroring each other's movements: the *mirror game*. The mirror game is a common exercise in theatre practice (Spolin, 1999), used to promote actors' ability to enter and remain in a state of togetherness (Schechner, 1994). We used an experimental paradigm that consists of a device that gives quantitative and automated indicators for the quality of interaction during the mirror game (Hart, Noy, Feniger-Schaal, Mayo, & Alon, 2014; Noy, Dekel, & Alon, 2011). Players move handles along parallel tracks and are instructed to play together and mirror each other. The game has three rounds that allow the participants to experience different roles and interactions: in the first round one player leads and the other follows, then they switch roles, and the last round has no designated leader or follower role.

Previous studies found that players showed intervals of "togetherness motion", in which motion was complex, smooth and synchronized. This togetherness motion occurred most frequently when no leader or follower was designated (Noy et al., 2011). Hence, this paradigm allowed the quantification of the synchrony between two players. More recent works found correlations in physiological parameters and the experience of togetherness in the mirror game (Noy, Levit-Binnun, Alon, & Golland, 2015); studied the individual characteristics of motion (Hart et al., 2014; Noy, Alon, & Friedman, 2015); and utilized the mirror game as a platform for rehabilitation (Zhai, Alderisio, Tsaneva-Atanasova, & di Bernardo, 2014). In the present study we explored the mirror game paradigm as an indicator for attachment behavior, which we validated using one of the central measures of attachment in adulthood: the Adult Attachment Interview (AAI) (George, Kaplan, & Main, 1985, 1996).

The AAI is a semi-structured interview that was used in more than 200 studies, and measures current state of mind regarding childhood attachment experiences (Bakermans-Kranenburg & van IJzendoorn, 2009). In this study, we used the AAI to examine how the Internal Working Model of attachment was expressed in dyadic motion interaction, thus, exploring the connection between internal representation and external behavior during the mirror game.

We hypothesized that the mirror game includes ingredients that provide access to the expression of the Internal Working Model. There are at least two such ingredients: first, the mirror game entails an interpersonal interaction. This can activate the subject's Internal Working Model of attachment that guides the way one behaves in the presence of the other; for example, how one seeks for proximity, regulates her or his own anxiety, and synchronizes with the other. Second, the mirror game entails exploratory behavior: searching for possible patterns of joint motion. Thus, it can tap into the subject's attachment behavior, especially in the first stage of the game (see below) when the subject has the role of the leader. In this role, the player needs to both initiate motion and to take care not to "lose" the follower. This requires a second-by-second negotiation of needs, which may present an opportunity to assess attachment-related behavior and the expression of the Internal Working Models. Thus, in this pilot study we wanted to explore *if and in what ways different attachment styles are manifested in the mirror game*.

Method

Ethics Statement

The Institutional Review Board (IRB) at the University of Haifa approved the described experiments, including the written consent procedure (approval number 086/13). All of the participants provided their written informed consent to participate in the study.

Participants

Forty-nine participants started the study. Two participants were taken out of the data: one quit in the interview session, the other was taken out due to technical problems with the mirror game device. Therefore we analyzed the data for 47 participants, 22 females, mean age = 33.2 (*SD* = 7.3), mean number of year of education = 19.5 (*SD* = 2.6); 27 married, 4 divorced, 8 engaged in a relationship, 8 single; 24 have no children, 45 native Hebrew speakers. Participants were students and staff at the Weizmann Institute of Science, who volunteered to take part in the study.

We found no significant correlation for the mirror game variables or AAI scores with demographic variables (age, numbers of years of education, marital status, mother tongue, number of children). The only exception was a correlation between mirror game variables and gender. However, since there were only two experimenters playing the mirror game, one male and one female, such that all male participants played with the male experimenter and all females participants played with the female experimenter, this gender correlation may reflect some individual difference between experimenters other than gender.

Procedure

The participants took part in two sessions. In the first session, they played the mirror game with the same gender-matched expert player. In the second session, participants were individually interviewed by an experienced AAI interviewer. This study was part of a larger project that explored the mirror game paradigm to study adult's interaction (see Hart et al., 2014).

The mirror game set-up

A customized device measured the linear motion of two handles at 50 Hz on parallel 585 mm-long tracks, with spatial accuracy of 1 m (Figure 1). A set of lights indicated the type of round (blue leads, red leads, or no designated leader). Players were instructed to produce mirror-like motion together, with or without a designated leader.

The game had three rounds, each round was 3 minutes: the participant led first, then the experimenter led, and the last round was with no designated leader (see full instruction for the MG in Appendix 1). Motion traces were analyzed by automated algorithms for three measures described in the results section: (i) relative velocity difference between players (dV), (ii) percent of co-confident motion, and (iii) motion complexity.

The Adult Attachment Interview

(AAI; George et al., 1996). This is an hour-long semi-structured interview that involves a series of questions about childhood relationships with one's parents. Respondents

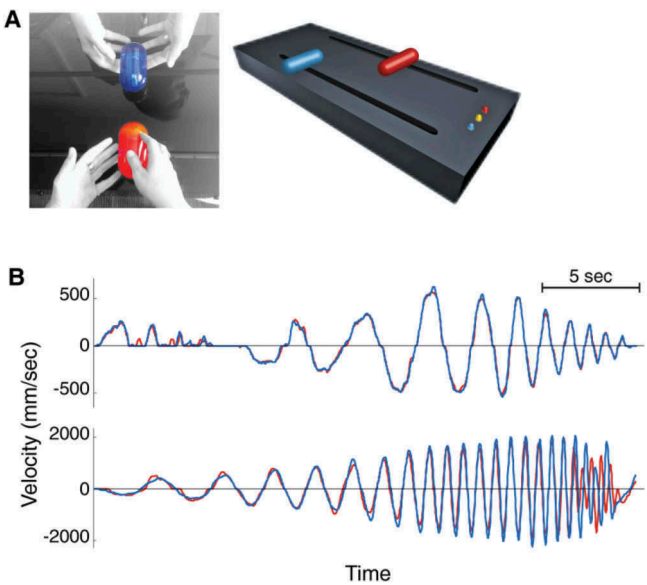

Figure 1. The mirror game device allows high resolution measurement of the motion of two players. (A) Improvised motion in the one-dimensional mirror game, in which players move handles along parallel tracks, was measured at high spatial and temporal resolution. Lights indicate type of round: red leads, blue leads, or no designated leader (joint improvisation). (B) Two examples of the resulting velocity traces of the red and the blue players, showing complex motion patterns created together.

support their relationship descriptions with specific episodic memories. Respondents are also asked about possible bereavement and abuse. The interview is transcribed verbatim and coded according to Main, Goldwyn, and Hesse's (1998) system. Individuals are assigned to one of three major classification based on their discourse during the AAI: The Secure-Autonomous (F) classification is associated with responses that are coherent, clear, relevant, and reasonably succinct and are generally "free to explore" their childhood memories-good or bad- in an open and exploratory manner. The transcripts of Insecure-Dismissing individuals (Ds) tend to involve idealization (overly positive generalizations not substantiated by specific memories) and/or insisting on inability to recall specific memories. In addition the dismissing individuals tend to rely mostly on himself/herself, and minimize the significance of past experiences. Insecure-Preoccupied (E) transcripts are typically characterized by lengthy, emotionally charged narratives that lack relevance and coherence. They also may be difficult to follow, but with a more passive tone. Additional classification is the Unresolved-Disoriented (U) that shows signs of disorientation when discussing potentially traumatic events. Unresolved transcripts are also assigned a secondary classification (Autonomous, Dismissing, or Preoccupied), which best describes the discourse when not discussing loss or abuse. Finally, the "cannot-classify" (CC) classification indicates a text that cannot be fitted any "organized" (Ds, E or F) AAI placement. This is evidenced most clearly when the text demonstrates a striking or unusual mixture of mental states (Hesse, 1996).

The interviews were transcribed verbatim and identifying information was removed prior to coding. Transcripts were coded by Nina Koren-Karie, a certified AAI coder trained by Mary Main and Erik Hesse. For reliability, a second certified AAI coder scored 21% of the study's interviews. Both coders were blind to all other project data and to the analysis and scores obtained by the other coder. Percent agreement across the five classifications, based on 21% of transcripts, was 97%, $\kappa = .96$, $p < .01$. In addition to employing the AAI categories we also applied the AAI scales as continuous measure using the coherence of mind scale. The interclass correlation (ICC) between the two coders' scores for this scale was .88.

Results

To test the relationship between people's behavior in the mirror game and their attachment classification, we measured $n = 47$ participants playing the mirror game and correlated the features of their motion with their scores on a standard AAI.

Mirror game analysis

For each player, we obtained the velocity profile as leader, follower, and in joint improvisation (no designated leader) conditions. In the first round, the participant was always the leader. Since this round was the first interaction between the participant and the experimenter, we focused in this study only on data from this first 3-minute round, in which motion is unbiased by leadership from the repeating expert player.

The motion was analyzed quantitatively and automatically according to the method of Noy et al. (2011). Specifically, the velocity of the subject (leader) and experimenter (follower) were compared at each time point (total of 3000 time points per game, a

resolution of 50 points per second). This velocity profile was used to compute three measures that characterize the motion. We calculated the mean relative error in velocity (dV): this indicated the average extent of difference between leader and follower velocities (see supplementary figures S1, S2). We also measured the fraction of time in which the two players showed synchronized and jitter-less motion. This motion is called *co-confident* motion, as defined in Noy et al. (2011), indicating the extent of "togetherness motion" in the interaction. We used an automated algorithm to detect the co-confident periods as described in detail in Noy, Levit-Binnun, et al. (2015) (see supplementary figures S3, S4). Finally, we evaluated the motion complexity, by means of a wavelet transform approach as described in Noy et al. (2011). This method quantitates how many basic temporal patterns – wavelike curves of defined duration called wavelets – are needed to accurately describe the motion. Simple motion can be described by only a few repeating wavelets and complex motion requires many wavelets of different frequency and duration (see supplementary figures S5, S6).

The three measures were designed to reflect different attributes of the interaction. dV and Co-Confident measures two different aspects of motion synchrony between the two players (dV – global velocity error; Co-Confident – the existence of jitterless and synchronized segments). Complexity measures how many basic elements are needed to describe the motion trace produced by one player. To test whether these measures capture different aspects of the motion we computed the correlations between the three measures. We found all correlations to be non-significant.

Histograms of the distributions of the three kinematic measures, across all games, are shown in Figure 2. Because some of these measures were not normally distributed, we used Mann-Whitney tests in the analysis.

To test the stability of the three measures we assessed test-retest stability within the current design. The motion in the third round is produced without a designated leader,

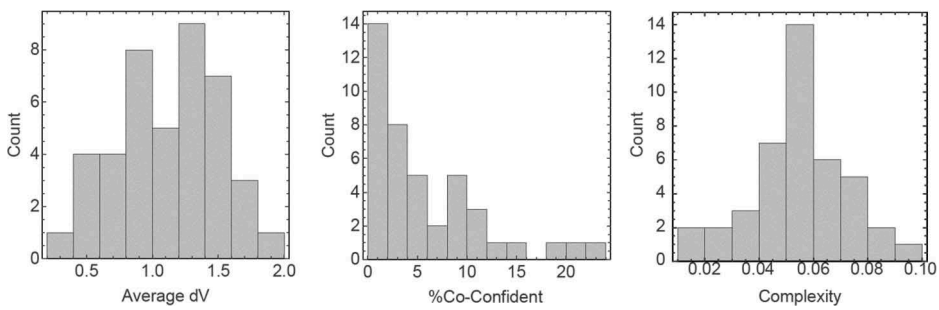

Figure 2. Distributions of kinematic measures across all participants. The distributions of the three kinematic measures in all games are shown, combining the different attachment style groups. All data is from the first round in the game, where the participants were leading the motion. Kinematic variables: Average dV = the average relative velocity error between the two players, over the whole round; % Co-Confident = percentage of round time that was identified as co-confident periods, synchronized motion of the two players without jitter; Complexity = complexity of the leader motion, estimated by the compression ratio needed for a good reconstruction error (95%), using Wavelets decomposition. Although we later show significant differences between groups with different attachment styles, we note that there are overlaps between the groups in these measures, and that the distributions are not bi-modal.

and is assumed to be produced by both players. We therefore tested if the values of the measures in the third round are related to the values from the first two rounds. For each of the three measures we computed the correlations of (1) the average of the measure in the first two rounds (designated leaders), and (2) the measure in the third (joint) round. For the Complexity measure, which is not a dyadic measure, we computed for the third round the average between the two players. A medium and significant Spearman correlation was found for the three measures across the three rounds (dV: $r = 0.65$, $p < .0001$; Co-Confident: $r = 0.39$, $p < .01$; Complexity: $r = 0.36$, $p < .05$). We conclude that the three measures show some test-retest stability in the current design.

Adult Attachment Interview analysis

Each player was interviewed and the interview was scored according to standard methodology. Players were classified as secure (F, 21 participants, 47%) or insecure (53%). In the insecure category, most were in the subcategory of insecure-dismissive (DS) (21 out of 26). The other three players had an insecure-preoccupied (E) classification. A fourth player had an unresolved classification (U), and a fifth had a CC interview. Due to the small number of participants in the E, U and CC groups, we decided to focus on comparing the secure to the insecure-dismissive group. We therefore removed these five players from the dataset, resulting in a final dataset of 42 participants.

We used the Mann-Whitney test to calculate the difference between secure and insecure attachment on the kinematic measures of the mirror game (see Figure 3 for the Box-Whisker plots of the distributions of the three kinematic measures). In addition, following Cumming (2014), we calculated the effect size using rank-biserial correlation (see Figure 4). The findings show that participants that were categorized on the AAI as secure had larger relative errors in velocity ($U = 113$, $n1 = 19$, $n2 = 22$, $p = .01$, $r = .46$) lower fraction of time spent in synchrony ($U = 293.5$, $n1 = 19$, $n2 = 22$, $p = .03$, $r = -.4$) and higher complexity of motion ($U = 125$, $n1 = 19$, $n2 = 22$, $p = .03$, $r = .4$) than insecure attachment.[1]

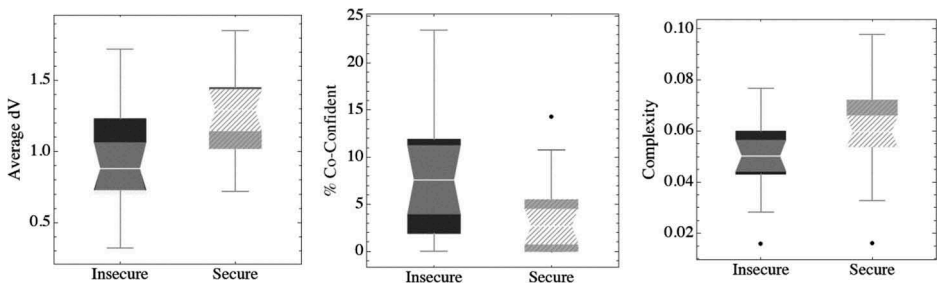

Figure 3. Distributions of kinematic measures for participants with secure and insecure attachment styles. Box-Whisker plots of the distributions of the three kinematic measures, for secure ($N = 21$) and insecure ($N = 21$) participants are shown. Participants were tagged as secure/insecure according to their score in the AAI. The grey (for secure) and light grey strips (from insecure) boxes span the range from the first to the third quintiles, around median values (white line). The whiskers represent the minimal and maximal values, without outliers (represented as dots). Outliers are defined as points behind 1.5 the inter-quantile range from the edge of the box.

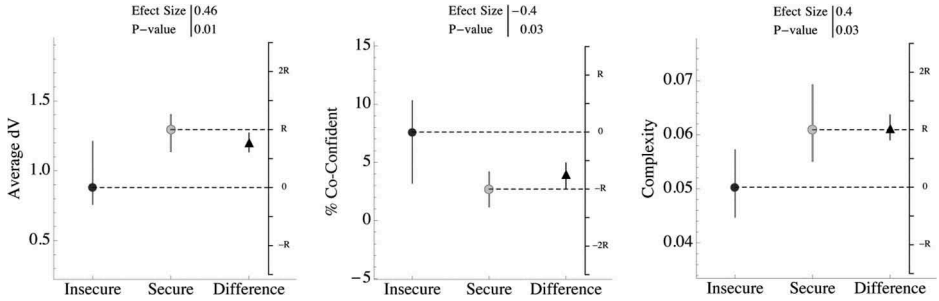

Figure 4. Secure participants tend to produce less synchronized and more complex motion in the mirror game. Medians (circles) and 95% confidence interval for median estimation (lines) are shown for insecure (dark grey) and secure (light grey) participants, for the three kinematic measures. Also shown in each panel is the 95% confidence interval for the estimated median difference using bootstrapping, normalized to the observed difference (R). Secure participants, acting as leaders in the MG produced motion that contained more error between leader and follower (Average dV); has less highly synchronized and smooth segment (% Co-Confident) and showed more complexity in their motion tracks (Complexity).

Next we wanted to consider the AAI scales as continuous measures. Given that *coherence of mind* in the AAI is presumed to reflect the core of an individual's attachment state of mind (Hesse, 2008; Main, Goldwyn, & Hesse, 2008), we examined the correlation between the coherence of mind scale and the mirror game kinematic measures. dV showed significant correlation with the coherence of mind scale, that is, more errors with higher coherence (r = .386, p = .01), Co-Confident showed significant negative correlation with coherence scale, that is, less synchronized segments with higher coherence (r = -.330, p = .03), and Complexity was close to significance (r = .266, p = .08).

Discussion

This study links two different methodologies: the AAI which is a verbal test of inner representations coded by experts, and the mirror game, which is an automated assay of dyadic motion interaction. Our findings show a connection between dyadic motion and attachment classification in adulthood. A priori, one should not necessarily expect that a fine grained analysis of a simple dyadic motion interaction could carry information about adults' attachment behavior. The present preliminary results make such a connection. This represents an objectively and automatically measurable behavior correlated to a key psychological construct.

Similar to our study, the study of microanalysis of face-to-face interaction of parents–infants uses short time-units (usually 1 minute) to explore, in detail, interpersonal coordination during interaction and compares it to attachment classification. For example, Jaffe, Beebe, Feldstein, Crown, and Jasnow (2001) established a link between vocal synchrony using a computed time series analysis and attachment style (see more examples in Beebe et al., 2010; Feldman, 2007). In the present study, we looked at interpersonal coordination at higher resolution (50 Hz) using an automated analysis of the interaction. Similar to the face-to-face microanalysis studies, we established a link between dyadic movement and attachment classification. Our correlation thus

expanded the results of previous studies in the context of parent–child interaction to the context of two adults playing together.

We found that participants who were secure on the AAI showed more errors and less synchrony when playing the mirror game than participants who were insecure-dismissing on the AAI. In addition, the secure participants showed a more complex and diverse game, so that a larger variety of patterns characterized their game. Thus, it seems that secure participants, while playing together and keeping in synchrony, allowed themselves more freedom to explore during the game.

These findings may be understood using the concept of *contingent coordination* that is used in the context of attachment theory (Beebe & Steele, 2013). Contingency coordination is defined as the level of adjustment of the mother to the child's behavior, hence, how closely she follows and corresponds to the child's behavior. Contingency coordination is central to the study of mother–child interaction as a predictor of quality of attachment (Beebe & Steele, 2013).

Beebe and Steele (2013) suggest the *midrange model of interactive contingency* in which both poles of higher or lower degree of contingent coordination leads to insecure attachment. A number of studies support this model, showing that mothers of secure children show a moderate degree of contingent coordination when interacting with their children, compared to mothers of insecure children (see for example Malatesta, Culver, Tesman, & Shepard, 1989; Slade et al., 1995).

Studying vocal rhythm coordination at four months old, Jaffe et al. (2001) found that higher contingency coordination ("trying too hard" or "vigilance") increased the predictability of insecure attachment. They suggest that mid-range coordination may leave more space for uncertainty, initiative, and flexibility within the experience of correspondence and contingency, optimal for secure attachment (Fonagy & Target, 1999). These findings imply that flexibility and lack of rigidness characterize the interaction of mothers and their children with secure attachment.

Using these theoretical concepts, we suggest that secure adult players showed midrange levels of contingency coordination in the mirror game. They allowed themselves flexible exploratory behavior, without disengaging from the other player. Hence, security of attachment was correlated with moderate level of synchrony and high level of errors and a less rigid game, compared to insecurity-dismissing attachment.

Another relevant study that explored the characteristic of quality of attachment in terms of flexibility vs. rigidness is a longitudinal study that tested children's (age 50–61 months) decision-making based on perceptual cues, mother's claims, and a stranger's claims (Corriveau et al., 2009). The study showed that children with secure attachment display a mix of trust and autonomy in regard to their mother's claims and showed a flexible, sometimes self-reliant, strategy. In contrast, insecure children showed rigidity and lack of flexibility in their strategy.

Similarly, Bernier and colleagues (Bernier, Matte-Gagné, Bélanger, & Whipple, 2014) recently showed that exploration and autonomy are components that connect mothers' state of mind and child's quality of attachment. In this work secure-autonomous mothers, as measured by the AAI, showed maternal behavior that support autonomy and exploration while interacting with their child, which in turn is connected to the child's secure attachment (Bernier et al., 2014).

Our study adds findings from adults to the above-mentioned parent–children studies. We found that insecure-dismissing was related to a more rigid strategy with less space for "errors" and exploration of the game. During the mirror game, the secure-autonomous adult displayed freedom to explore new territories without the need to stick rigidly to the other. The observed differences in the behavior in the mirror game between secure and insecure participants may have implications for other contexts of adult dyadic exploration – differences to be tested in future studies.

Our exploratory data analysis needs further support. This pilot study was limited in its small size sample and its distribution of attachment classification, having mainly an insecure-dismissing classification. Follow-up studies with representative sample covering all insecure attachment groups, could help to clarify the expression of attachment in the mirror game more thoroughly. Larger and more representative samples will also allow exploring the possible role of gender.

In addition, it would be of interest to see if differences in the mirror game can be predicted also by simpler, self-report instruments such as the ECR (Brennan, Clark, & Shaver, 1998). Another future direction may expand this paradigm and use a mirror game involving the whole body to explore the expression of the Internal Working Model in a more complex movement interaction. As a non-verbal measure, the mirror game paradigm might also offer a new tool to study dyadic interaction in non-verbal populations, such as people with intellectual disabilities.

In the present study we offer a new paradigm supported by exploratory data analysis. Using this paradigm, we suggest that a simple movement interaction can reveal something about one's expectation, anticipation, and organization regarding meeting another person and playing together. Hence, a reductive measure of two people playing with each other may tap into the implicit knowledge of attachment. Thus, in this study we wished to expand the study of attachment into new territories, using high-resolution objective measures to study non- verbal interaction in adulthood.

Note

1. We repeated the statistical analysis including the four insecure participants and find that the conclusions remained the same

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1

Instructions for the mirror game

We will play the mirror game together. In this game, we will create movements together. This is not a competition. There is no right or wrong.

In the game there are three rounds, each round is 3 minutes long. In the first round you will be the "leader" so that you will make movements and I will imitate you accurately; then I will be the leader and you will imitate me; and in the third round, we will try to make movements together without a designated leader. Each round will start with a light followed by a sound that indicates the beginning of the round. The same sound will indicate the end of the round. The lights will indicate the beginning of each round. A blue light will indicate the beginning of the round that you lead, a red light will indicate the round that I lead, both lights together will indicate the third round with no designated leader. There will be a break of 10 seconds between the rounds. Before the game begins you will have a minute to practice moving the handle around the track. Any questions? So we begin.