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Mirroring Activity in the Brain and Movement Determinant in the Rorschach Test

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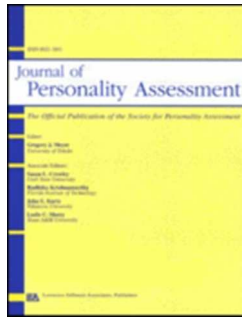
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Abstract

Human movement (M) responses to the Rorschach are related to cognitive sophistication, creativity, and empathy. Recent studies also link Ms to EEG-mu suppression, an index of mirroring activity in the brain. In this article, we further investigate the link between Ms and mu suppression, by testing some clinical interpretative distinctions. Previously collected EEG data recorded during the administration of the Rorschach were re-analyzed. We hypothesized that (1) among several responses investigated, only M would be associated with mu suppression and (2) Ms with active movement, ordinary form quality, or whole human figures would be most strongly associated with mu suppression. Hypothesis 1 was fully confirmed, thus supporting that the traditional interpretation of M has a neurobiological foundation. Hypothesis 2 was partially confirmed, i.e., active Ms were associated with mu suppression more strongly than passive Ms ($p < .05$), but no other significant differences emerged. Clinical implications are discussed.

Keywords: electroencephalography, human movement, empathy, mentalization, mirror neurons, Rorschach

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Mirroring Activity in the Brain and Movement Determinant in the Rorschach Test

In forming responses to the Rorschach test (Rorschach, 1921), respondents select among a variety of distinct perceptual features suggested by the inkblot stimuli. Such features are called determinants and help to identify or determine the specific representation or imagery in the response. They include form (contour) of the blot (e.g., “it looks like a person because of the shape”), color (e.g., “the shape and the color make it look like a red hat”), and shading (e.g., “a person surrounded by smoke because of the shading there”). All these features are pulled directly from the actual characteristics of the stimuli that indeed have different ambiguous shapes and are pictured with various colors and achromatic nuances. There is a fourth, atypical class of determinants, referred to as “movement.” Rorschach stimuli are static images and obviously do not move. Unlike other determinant classes, which are actually contained in the figure, perceived movement (e.g., “two people dancing together”) is added to the stimulus field, presumably, as a product of ideational and imagined activity of the respondent as he or she “experiences” the sensation that the seen object is moving. Since the publication of Hermann Rorschach’s monograph (1921), human movement (*M*) responses to the test are almost unanimously considered as one of the best sources of information about personality dynamics. For example, Mayman (1977) argued that *M* responses are “the richest, most revealing, consistently more interesting responses which occur on the Rorschach test” (p. 230); and Piotrowski (1977) said that they “provide, more than any other single test component, specific and significant information about the individual’s role in the interhuman relationships that matter to him” (p.189). This additional interpretive value attributed to *M* responses by outstanding authors of the century-long history of the Rorschach test might be one of the reasons why this determinant category has been retained in all the Rorschach systems despite the major changes that have occurred from

one system to another (e.g., Beck, 1944; Exner, 1969, 2003; Klopfer & Kelley 1944; Meyer, Viglione, Mihura, Erard, & Erdberg, 2011; Piotrowski, 1957).

Human Movement in the Rorschach Test

Three types of movement responses occur in the Rorschach test, human movement (M), animal movement (FM), and inanimate object movement (m). Rorschach paid particular attention to the human movement. He believed that when producing a human movement response, individuals identify themselves with the human figure seen in the stimulus, as if they were performing the same movement (Malmgren, 2000; Rorschach, 1921). This process was referred to as “kinesthesia”¹. Importantly, Rorschach believed that such kinesthetic identification would only be possible when the response object is a human being in movement (e.g., “a woman dancing with hands up”). That is, the kinesthetic identification does not occur when the response object is an animal making a movement confined to the animal species (e.g. “a bird flying in the air”). It would also not occur when the response involves an inanimate object in movement (e.g., “smoke rising up”). Historically, only Beck (1944) and to some degree Rapaport, Gill, and Schafer (1946) defended Rorschach’s position and did not score non-human movement. Other systems, including the Comprehensive System (CS, Exner, 2003), distinguished between the three types of movement responses and argued that they corresponded to distinct psychological operations and interpretations.

All of the Rorschach systematizers have conceived *M* responses as indices of higher level cognitive functioning, although from different perspectives, and with some distinctions. In fact, in order to recognize a static human figure as a person who is doing something, it is likely some sort of representation or even a feeling of movement should be present in the mind of the subject who is looking at the card. Stated differently, the subject likely invokes higher-level cognitive processes, possibly imagination, creative thinking, identification with another human being, or a perspective-taking approach, etc. (Exner, 1969). In the Klopfer

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3 system (Klopfer & Kelley, 1944), *M* serves as the basic indicator of a well-functioning
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5 personality. *M* bridges the gap between inner resources of drive and fantasy and the outward
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7 orientation of reality testing and object relations or interpersonal schema. It incorporates
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9 creative capacities, the acceptance of one's own self and inner promptings, and the richness
10
11 of the inner life. According to Beck (1944), *Ms* represent those strong emotions that the
12
13 individual is able to contain internally, thereby converting them to adaptive and creative
14
15 processes. Piotrowski (1957) expressed a more articulated view of *M* responses, suggesting
16
17 that they always imply interest in people, awareness of the self, concern with the future, and
18
19 mostly the subject's "role-in-life," which reflect basic characteristics of the personality.
20
21 According to him, *Ms* stand for the most individual and integrated strivings that dominate the
22
23 individual's life and indicate traits stabilizing the relation between the individual and his
24
25 environment. They are potential actions, rather than actual actions; initial stages of actions at
26
27 a very low level of intensity. From the perspective of the psychodynamic model of Ego
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29 Psychology, Rapaport et al. (1946) claimed that *M* responses indicate the ability to delay the
30
31 individual's emotional response, the readiness to make anticipations, and the flexibility of
32
33 perceptual and associative processes in general. Borrowing from all these traditions, Exner
34
35 (2003) focused on the cognitive aspects of the *M* response and noted that it involves the
36
37 elements of reasoning, imagination, and higher forms of conceptualization; a form of delay
38
39 from yielding to more spontaneous responses to the environment during which time an active
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41 and deliberate form of directing one's inner life occurs. He gave less emphasis to the social
42
43 cognition² component, although he did acknowledge the importance of the identification
44
45 mechanism upon which the *M* response is presumably based.
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52 Traditionally, and particularly in the CS, *M* responses delivered in association with
53
54 perceptual distortions (Form Quality *minus*, *FQ-*) and/or embellishment of various kinds
55
56 (*Special Scores*) are considered as particularly likely to reveal underlying problematic aspects
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3 of personality, because individuals are putting in the blots idiosyncratic features that go
4 beyond the stimulus properties (Meltzoff, Singer, & Korchin, 1953; Weiner, 2003). *M*
5 responses characterized by *FQ*- (i.e., perceptual distortion), for example, are thought to
6 reflect impaired representations of a human being, and the lack of realistic understanding of
7 others' thoughts, feelings, and intentions. The specific type of movement described in the *M*
8 response, is believed to reveal key information as well. *M* responses characterized by active
9 (e.g., "a person lifting an object") versus passive (e.g., "a woman being lifted up by a
10 U.F.O.") movements, for instance, reflect very different attitudes in terms of propensity for
11 passive versus active imagery involving people (Exner, 2003). This is also believed to extend
12 to the real life attitudes towards interpersonal relationships. In fact, a predominance of active
13 *M* responses has been found among women employed as strippers, in contrast to a relative
14 predominance of passive *M* responses among women employed as models (Young &
15 Wagner, 1993). Another important distinction, finally, is the difference between *M* responses
16 associated with whole human figures (pure *H*) and *M* responses associated with non-whole
17 human figures (non-pure *H*). Indeed, pure *H* is the only content coding category used for
18 responses that include whole real people, whereas human details and human-like figures refer
19 to partial human body and fictional people. Whole human contents are therefore thought to be
20 chosen by those whose self-image is based more on identifications with real persons while
21 non-whole human figures are likely to be selected by those whose self-image is based more
22 on imagination or internal representations that coincide less with reality. Thus, *M* responses
23 associated with pure *H* are believed to be more desirable and optimal kinds of responses as
24 compared to *M* responses associated with non-pure *H*.

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52 In line with most of the theories described above, a wide body of empirical research
53 has shown that *M* responses are associated consistently with ideational and social processes
54 including field independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), effective
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3 interpersonal relations and behaviors (Exner, 2003), ego strength and introversion
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5 (Greenwald, 1991; Hix et al., 1994), ability to cognitively process emotions (Porcelli &
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7 Meyer, 2002; Porcelli & Mihura, 2010; Ruhe & Lynn, 1987), creativity (Ferracuti, Cannoni,
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9 Burla, & Lazzari, 1999), dream recall (Orlinsky, 1966), and intelligence (Gallucci, 1989;
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11 Wood, Krishnamurthy, & Archer, 2003). *M* has also been associated with sensory deprivation
12
13 (Bendick & Klopfer, 1964), electromyography-based muscle potentials (Steele & Kahn,
14
15 1969), ability to discriminate florid and withdrawn schizophrenics from healthy subjects (Di
16
17 Nuovo, Laicardi, & Tobino, 1988), and symptom improvement after psychotherapy (Exner &
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19 Andronikof-Sanglade, 1992; Weiner & Exner, 1991).

22
23 Synthesizing the available empirical research leads to the conclusion that the *M*
24
25 responses may be considered indices of higher cognitive functioning (because *M* involves the
26
27 integration of different perceptual features and individual psychological involvement), ability
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29 to imagine (because the actual stimuli do not move), and empathy (because of the implied
30
31 ability to identify with a human being) (Exner, 2003; Exner & Erdberg, 2005). *Ms* are
32
33 strongly linked to the individual's ability and tendency to evoke an internal experience of
34
35 movement from an ambiguous stimulus and to involve this experience of movement in the
36
37 perceptual processing of static pictures. The psychological process eliciting *M* responses
38
39 resembles theoretical constructs such as *Einfühlung* (a German term meaning literally
40
41 "feeling-into" which has been used in the experience of art indicating the immediate physical
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43 responses generated in the observer by the exposure to art painting), empathy (the ability to
44
45 put oneself in the place of another in terms of actions, sensations, and emotions), and also
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47 mentalization (the cognitive mechanism that allows one to ascribe goals and intentions to
48
49 others). This process is consistent with main theoretical concepts and models in the field of
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51 psychological functioning, as the psychodynamic mechanism of identification (Gabbard,
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53 2005) and the construct of vicarious learning (Bandura & Walters, 1964). Also, the human
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3 capacity to pre-rationally make sense of the actions, emotions, and sensations of others
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5 depends on ‘embodied simulation,’ a functional mechanism through which the actions,
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7 emotions, or sensations we see activate our own internal representations of the body states
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9 that are associated with these social stimuli, as if we were engaged in a similar action or
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11 experiencing a similar emotion or sensation (Freedberg & Gallese, 2007). A growing body of
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13 studies published in the last two decades supports the ‘shared manifold hypothesis’ that the
14
15 brain substrate linking the bridge between embodied simulation and *Einfühlung*, empathy,
16
17 and mentalization may be constituted by the mirror neuron system (MNS, Gallese, 2001;
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19 Hurley, 2008).

22 **The Mirror Neuron System (MNS)**

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25 Mirror neurons are cortical brain cells that fire during both the execution and the
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27 observation of motor behavior. They were discovered during single cell recording of the
28
29 ventral premotor cortex (area F5) in macaque monkeys that either performed an action or
30
31 observed the same action performed by another monkey or an experimenter (di Pellegrino,
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33 Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996;
34
35 Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). However, mirror neurons were not activated
36
37 when a monkey merely observed a static object or when it observed a screen with several
38
39 points moving randomly. This line of research supported the notion that the MNS subserves
40
41 observation-execution matching system, a possible mechanism by which action recognition,
42
43 action understanding, and imitation can be achieved (Gallese et al., 1996; Rizzolatti, Fogassi,
44
45 & Gallese, 2001; Umiltà et al., 2001).

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49 Single-unit recording is not typically performed in the human brain (although see
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51 Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). However, indirect population-level
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53 measures support the existence of a functional analogous system to macaque MNS in the
54
55 human inferior frontal gyrus (IFG) (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni et
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3 al., 1999) through transcortical magnetic stimulation (TMS, Fadiga et al., 1995; Maeda,
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5 Kleiner-Fisman, & Pascual-Leone, 2002; Strafella & Paus, 2000), positron emission
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7 tomography (PET) (Parsons et al., 1995), functional magnetic resonance imaging (fMRI)
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9 (Buccino et al., 2004; Grézes, Armony, Rowe, & Passingham, 2003; Iacoboni et al., 1999),
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11 and electroencephalography (EEG) (Cochin, Barthlemy, Lejeune, Roux, & Martineau, 1998;
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13 Muthukumaraswamy & Johnson, 2004; Oberman, McCleery, Ramachandran, & Pineda,
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15 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda, Allison, & Vankov, 2000;
16
17 Pizzamiglio et al., 2005; Rizzolatti et al., 2001). Further, data are consistent with the idea that
18
19 the frontal MNS in humans may be part of a broader network of brain regions including the
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21 inferior parietal lobule (Buccino et al., 2001; Parsons et al., 1995), the superior temporal
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23 sulcus (Iacoboni et al., 2001), sensorimotor cortex (Pineda, 2008), and regions of the limbic
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25 system (Morrison, Lloyd, di Pellegrino, & Roberts, 2004; Singer et al., 2004; Wicker,
26
27 Keysers, Plailly, Gallese, & Rizzolatti, 2003). This broader network suggests that the MNS
28
29 may play a more sophisticated role than pure imitation.
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34 In humans it is speculated that mirror neurons represent not only the physical aspects of
35
36 an action but also the underlying intentions, thoughts, and feelings that motivated that action.
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38 Said differently, perhaps they provide the neural basis for unique human social skills such as
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40 empathy, theory of mind, and facial emotion processing (Gallese, 2001, 2006; Gallese &
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42 Goldman, 1998; Pelphrey & Morris, 2006; Rizzolatti, Fabbri-Destro, & Cattaneo, 2009;
43
44 Uddin, Iacoboni, Lange, & Keenan, 2007) that allow effective social cognitive processes and
45
46 interactions. Crucial to our work are recent investigations with non-clinical populations of the
47
48 proposed link between the MNS and social cognitive functions such as empathy (Gazzola,
49
50 Aziz-Zadeh, & Keysers, 2006; Kaplan & Iacoboni, 2006; Pfeifer, Iacoboni, Mazziotta, &
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52 Dapretto, 2008) and facial emotion processing (Enticott, Johnston, Herring, Hoy, &
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54 Fitzgerald, 2008; Sato & Yoshikawa, 2007; Wicker et al., 2003).
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3 An intriguing issue related to MNS activity is the role played by the nature of the
4 perceptual stimuli. The visual feature that activates mirror neurons is the observation of a
5 significant interaction between the agent of the action (e.g., seeing a hand grasping) and the
6 object being the target of it (e.g., a tea cup). Mirror neurons in monkeys typically do not
7 respond to the observation either of a hand merely miming an action or an object alone, even
8 when the object is of interest (e.g., food). In other words, mirror neurons are part of a neural
9 matching system that allows the observer, during action observation, to place her or himself
10 in the same “internal” situation as when actively executing the same action. An important
11 experiment showed that the MNS in monkeys responds when the final part of an action, most
12 crucial in triggering the response in full vision, was hidden to the observer, i.e., when the
13 intention of the hand gesture could only be inferred (Umiltà et al., 2001). Similar results
14 emerged when the actual stimuli were not moving but rather static images from which
15 dynamic information were extracted (implied motion). For example, the medial
16 temporal/medial superior temporal cortex (MT/MST complex) is thought to activate during
17 the visual experience of real (as in movies) or illusory motion, namely when the observer can
18 infer the position of an object in a subsequent moment in time without seeing the actual
19 movement, such as seeing two photographs of an athlete before and after heaving the shot put
20 (Kourtzi & Kanwisher, 2000). Similarly, a TMS study indicated that the MNS is responsive
21 when dynamic information about body actions is inferred from static pictures of body
22 postures (photographs of pincer grips) (Urgesi, Moro, Candidi, & Aglioti, 2006).

23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 **Assessment of the MNS Activity with the EEG**

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49 Previous studies (Cochin et al., 1998; Oberman et al., 2005, Oberman, McCleery et al.,
50 2007; Oberman, Pineda et al., 2007; Pineda et al., 2000) have linked activity in the human
51 MNS with activity in the EEG mu frequency band recorded over sensorimotor cortex. At rest,
52 these sensorimotor neurons spontaneously fire in synchrony (Gastaut, 1952), leading to large
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3 amplitude EEG oscillations in the 8–13 Hz (μ) frequency band. When subjects perform an
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5 action, these neurons fire asynchronously, reflecting greater levels of active processing
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7 during motor movement and observation, and thereby decreasing the power of the μ -band
8
9 EEG oscillations (Pfurtscheller, Neuper, Andrew, & Edlinger, 1997). Over the past 50 years
10
11 there have been several theories relevant to the function of the μ rhythm (for a review, see
12
13 Pineda, 2005). Most recently, results of several studies have uncovered various properties of
14
15 μ suppression that directly link it to the frontal mirror neuron system. First, μ power
16
17 recorded from electrodes over sensorimotor cortex (scalp locations C3 and C4; Figure 1) is
18
19 reduced by self-initiated movement and observed movement (Babiloni et al., 1999; Cochin et
20
21 al., 1998; Gastaut, 1952; Oztop & Arbib, 2002; Pineda et al., 2000). Importantly, similar to
22
23 mirror neuron activity, the μ wave does not respond to nonbiological directional motion
24
25 such as bouncing balls (Oberman et al., 2005). Furthermore, analogous to previous fMRI
26
27 studies of the MNS (Buccino et al., 2001), the presence of a target object increases μ wave
28
29 suppression as compared to pantomimed actions (Muthukumaraswamy & Johnson, 2004;
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31 Muthukumaraswamy, Johnson, & McNair, 2004).
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36 Since the μ rhythm is generated by activity in sensorimotor areas (Gastaut, 1952),
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38 and mirror neurons are located in premotor cortex, it has been hypothesized that the μ
39
40 rhythm may specifically index downstream modulation of primary sensorimotor processing
41
42 by mirror neuron activity (Muthukumaraswamy & Johnson, 2004; Pineda, 2005).
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45 **Rorschach M Responses and the Mirroring Activity**

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47 As stated previously, the brain location of the MNS network indicates that these
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49 neurons code not only for specific, actual motor acts performed by the individual or seen in
50
51 another individual, but, by virtue of being wired to neurons that code for the subsequent
52
53 motor acts, they facilitate the activity of these downstream neurons. Briefly, mirror neurons
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55 predispose the individual to subsequently perform the smooth execution of the intended
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3 action, thus favoring the notion that the MNS mediate action understanding behind the
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5 observed motor act (Rizzolatti et al., 2009). For example, mu wave suppression to EEG has
6
7 been observed in children with autism spectrum disorder when a familiar person performed a
8
9 deliberate action but not when it was performed by an unfamiliar person (Oberman,
10
11 Ramachandran, & Pineda, 2008).
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14 The fact that mirror neurons discharge when the subject understands the potential
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16 action or the subjective intention to perform an action (i.e., observing not only another
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18 individual drinking a glass of beer but also the picture of a human hand close to a glass of
19
20 beer or even the glass of beer alone) has allowed us to advance the hypothesis that the MNS
21
22 would be activated also when one imagines a movement in a static picture without the actual
23
24 movement (for example, see studies linking imagination and EEG alpha/beta activity such as
25
26 Pfurtscheller et al., 1997). We speculated that such mentalization is very close to what is
27
28 thought to occur when an individual articulates the *M* response while observing the
29
30 Rorschach stimuli, namely when actions are mostly generated “internally,” within the
31
32 individual’s experience (feeling of motion), and triggered by minimal indirect cues placed
33
34 “externally,” in the actual static picture itself.
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39 In a first study (Giromini, Porcelli, Viglione, Parolin, & Pineda, 2010), EEG data from
40
41 15 undergraduate students were collected during baseline and three conditions (experimental,
42
43 contrast, and control) while they were observing the Rorschach cards on a video screen. In
44
45 the experimental condition (attribution of human movement), the participants were asked to
46
47 look at four Rorschach cards: two cards (III and VII) with the highest frequency of *M*
48
49 responses and two cards (V and VI) with the lowest frequency of *M* responses in the
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51 Rorschach CS reference database (Exner & Erdberg, 2005). While viewing the card,
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53 participants had to think of the answer to the question “What might this be?” Because of the
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55 technical constraints determined by the EEG procedure, they were required to look at the
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3 cards first and only later to verbalize their responses, thus avoiding uncontrolled artifacts in
4
5 the EEG recording. This slightly diverges from the standard Rorschach procedure of having
6
7 the liberty to immediately describe what one sees. In the contrast condition (identification of
8
9 human movement), the subjects were asked to observe the four Rorschach cards with
10
11 suggestions verbally provided by the experimenter during the visual exposure to identify a
12
13 commonly reported movement response (e.g., “two children doing something together”) on
14
15 the two cards with the highest proportion of human movement attribution, and a different
16
17 commonly reported response (e.g., “a tree”) on the two cards with the lowest proportion of
18
19 human movement attribution. In the control condition (observation of human movement), the
20
21 subjects were asked to observe non-ambiguous hand-made drawings specifically created to
22
23 resemble the Rorschach inkblots shown earlier, two representing a commonly reported
24
25 human movement response to the related inkblot (e.g., “two children doing something
26
27 together”) and the other two representing a different commonly reported response (e.g., “a
28
29 tree”).
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34 The results show that greater mu wave suppression occurred at C3, Cz, and C4 sites for
35
36 all the movement conditions when compared to the non-movement conditions; when actions
37
38 were either strongly suggested by the features of the stimuli (non-ambiguous drawings
39
40 closely resembling the Rorschach cards in the control condition), by verbal suggestions
41
42 verbally provided during the visual exposure to the stimuli (Rorschach cards used during the
43
44 contrast condition), and by the subjective internally generated representation of human
45
46 movement (Rorschach cards used during the experimental condition). As hypothesized, our
47
48 data show that mu suppression accompanies the Rorschach *M* responses.
49
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51 Those findings were limited, however, by the use of only four Rorschach cards and
52
53 technical issues such as the baseline condition in which subjects had to look at a white card
54
55 on a computer screen for 25 s without assessing the individual’s level of attention to the task.
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3 Conceivably, distraction, free-thinking, and boredom might have affected attention levels
4
5 later in the exposure period. Therefore, in our second study (Pineda, Giromini, Porcelli,
6
7 Parolin, & Viglione, 2011) we used a larger sample size (24 undergraduate students), all the
8
9 ten cards of the standard Rorschach test in the standard Rorschach CS procedure (Exner,
10
11 2003), a more appropriate control for baseline attention (participants were asked to engage in
12
13 a continuous performance task during the 90-s baseline period), and longer data collection
14
15 periods (600 s of EEG data recording). The results extended our previous findings in two
16
17 important issues. First, replicating earlier findings in a more ecological way, mu suppression
18
19 at central sites was greater in association to *M* responses compared to non-*M* responses
20
21 throughout all the ten Rorschach cards. Second, event-related desynchronization (ERD)
22
23 analyses showed that, unlike the non-*M* responses, when delivering *M* responses, mu
24
25 suppression occurred very early, during the first 1-2 s of exposition to the cards and remained
26
27 so for the entire exposure time. This may suggest that the mirroring phenomenon occurs prior
28
29 to the conscious decision of the subject to actually deliver an *M*-codable response.
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34 This second study, however, does not fully answer some important questions. First, by
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36 focusing only on the *M* response, and not other perceptual experiences or determinants (e.g.,
37
38 animal or inanimate movement responses, shading, etc.), one cannot address the discriminant
39
40 validity of the association between *M* responses and mirroring activity. In other words, our
41
42 second study did not rule out that the mu suppression phenomenon could also occur for other
43
44 Rorschach responses, such as shading, pure form or color responses. Establishing
45
46 discriminant validity is most important for *M* versus response features that share some
47
48 perceptual features with *M* but are interpreted differently, such as animal movement
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50 responses (*FM*, “a dog eating”), and non-moving human content responses (*m*, “the silhouette
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52 of a person”). Such research could test the traditional distinctive interpretation of the *M*
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54 response as an index of social cognition.
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3 A second important open question left from our previous studies concerns the
4 relationship between the mu suppression phenomenon and the typology of *M* responses. As
5 reviewed above, some *M* responses are interpreted favorably. *M* responses associated with
6 adequate rather than distorted perceptual elaborations, characterized by active rather than
7 passive movements, and formulated considering whole, real, persons rather than human-like
8 or partial figures are likely to indicate more mature and healthy psychological processes, and
9 are presumably related to superior social cognition abilities. Investigating the relationship
10 between mu suppression and typology of *M* would test these interpretive distinctions.

21 **Aims and Hypotheses of the Study**

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23 In the previous reports of our research (Giromini et al., 2010; Pineda et al., 2011), we
24 argued that the association between *M* responses and mirroring activity supports the
25 traditional interpretation of *M* responses, in that the MNS is thought to be a neurological
26 correlate of social cognition. In this article, we aim at further relating these
27 neurophysiological findings to the standard assessment practice, by analyzing different kinds
28 of Rorschach responses, and testing a number of clinical interpretative distinctions.
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36 Based on considerations and findings from earlier investigations, in this paper we
37 further hypothesize that:
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41 (1) The mu suppression phenomenon only occurs for Rorschach *M* responses because
42 of their association with social cognition and social competence and does not occur for other
43 perceptual experiences or determinants (e.g., animal or inanimate movement responses,
44 shading etc.,) which are not related to social cognition and social competence (Hypothesis 1:
45 “M vs. Other Determinants”);
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52 (2) Human movement responses expected to be more strictly related to social cognition
53 and social competence (e.g., adequately perceived human beings in movement) are more
54 strongly associated to mu suppression than human movement responses more related to poor
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3 social skills (e.g., distorted perceptions of human beings in movement) (Hypothesis 2:
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5 “Subtypes of M”).
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7 To investigate these two hypotheses we re-analyzed the data set published in Pineda et
8
9 al. (2011).
10

11 Method

12 Participants

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14 As described in Pineda et al. (2011), the sample consisted of 24 undergraduate
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16 students (17 women and 7 men) recruited from the Psychology Department’s subject pool at
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18 the University of California, San Diego (UCSD). Age ranged from 18 to 25 years ($M = 20.4$,
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20 $SD = 1.9$). All participants received class credits, and gave written consent. The study was
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22 approved by the Institutional Review Board at UCSD and was performed in accordance with
23
24 the ethical standards of the 1964 Declaration of Helsinki.
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29 Procedure

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31 Stimuli were shown on a screen situated at a distance of 96 cm, at a size of 17 x 24
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33 cm, similar to the original Rorschach cards. EEG data were collected during a baseline and an
34
35 experimental condition. During exposure to the stimuli participants were instructed not to talk
36
37 or move. The baseline condition consisted of watching a visual white noise for 90 s. To
38
39 ensure that participants attended to the screen, they were asked to engage in a continuous
40
41 performance task. Randomly, the screen turned red five times and blue four times, each color
42
43 change lasting for 1 s, during the 90 s baseline period. Participants were 100% accurate in
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45 their ability to count the number of time that the screen turned red.
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49 The experimental condition consisted of asking the participants to look at the ten
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51 Rorschach stimuli, one at a time in order, with the instruction to think of what they might be,
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53 consistently with the standard instructions of the CS (Exner, 2003). Two experimental
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55 sessions were included. During the first experimental session, each Rorschach image was
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3 presented right side up and remained on the computer screen for 30 s. Participants were
4
5 instructed to continue focusing on their one response for the entire period of EEG recording.
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7 At the end of each 30 s exposure, the image was removed from the screen and participants
8
9 were then asked to verbalize their response to the stimulus. All Rorschach cards were
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11 administered during this first experimental session. At the end of this session, participants
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13 were asked to repeat the entire task. All Rorschach cards were presented again in the same
14
15 standard order, with the participants being instructed to think, for each card, of a different
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17 response from what they articulated before. Except for this instruction, the second
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19 experimental session was identical to the previous one and was scheduled in order to obtain
20
21 sufficient amounts of clean EEG data.
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25 At the end of the two experimental sessions, a total of 20 responses and 600 s of EEG
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27 data (30 s per response) were collected.
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29 30 **EEG Data Acquisition**

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32 Data were collected from 13 electrodes embedded in a cap, at the following scalp
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34 positions: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, and O2, using the international 10–
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36 20 method of electrode placement (see Figure 1). EEG was recorded at a sampling rate of 500
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38 Hz and analyzed using a Neuroscan Synamps system (band pass 0.1–30 Hz). After removing
39
40 artifacts, the integrated power in the 8–13 Hz range was computed using a Fast Fourier
41
42 Transform. Mu suppression over sensorimotor cortex (scalp locations C3, Cz and C4) was
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44 calculated as the ratio of the power during the experimental condition relative to the power
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46 during the baseline condition (Pineda & Hecht 2009; Ulloa & Pineda, 2007). As a common
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48 procedure for this type of study (Altschuler et al., 2000; Bernier, Dawson, Webb, & Murias,
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50 2007; Martineau, Cochin, Magne, & Barthelemy, 2008; Oberman et al., 2005, Oberman,
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52 McCleery et al., 2007; Oberman, Pineda et al., 2007; Pineda & Hecht, 2009; Ulloa & Pineda,
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54 2007), a ratio was used to control for variability in absolute mu power as a result of
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individual differences such as scalp thickness, electrode placement, and impedance, as opposed to differences in brain activity. Since ratio data are inherently non-normal, as a result of lower bounding, a log transform was used for analysis (i.e., the log of the ratio was used). Indeed, a mu suppression index for each scalp location was computed for each card, corresponding to the log ratio of mu power during the observation of the card over the mu power during the baseline. A log ratio of less than zero indicates suppression.

Statistical Analyses

Several analyses were computed to investigate the effect of different response processes underlying various types of Rorschach responses on mu suppression.

Hypothesis 1: M vs. Other Determinants. We anticipated that, because the MNS is thought to be involved in social cognition, the human movement (*M*) responses should be the unique Rorschach response specifically associated with mu suppression unlike other types of responses such as non-moving human content (non-*MH* contents), non-human movement of animals (*FM*) or inanimate objects (*m*), color responses (*C*), shading-achromatic responses (*Y, T, V, C'*), and pure form responses (*F*) (Table 1). Thus, if these hypotheses were true, one should expect that mu suppression would be strongly associated only with human movement (Table 1, Category 1), and not associated with non-moving human content (Table 1, Category 2), non-human movement (Table 1, Category 3) or other important Rorschach determinants (Table 1, Category 4).

To test hypothesis 1, the association between mu suppression and the selected responses (e.g., non-human movement) was analyzed by implementing the same procedure that Pineda et al. (2011) adopted to investigate the association between M responses and mu suppression. Accordingly, the mean mu suppression during the observation of the cards with the selected response was compared to the mean mu suppression to cards without that response. For example, to investigate the relationship of non-human movement responses to

MIRRORING ACTIVITY AND RORSCHACH TEST

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3 mu suppression, (a) the mean mu suppression during the observation of the cards to which the
4 participants attributed *FM* or *m* responses was compared to (b) the mean mu suppression
5 during the observation of the cards to which participants did not attribute *FM* or *m* responses.
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7 The only one exception regards Category 2 of Table 1: given that it is likely that *M* responses
8 occur along with human contents, to avoid confounds this contrast was tested after excluding
9 all *M* responses from the analysis.
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16 This series of analyses aimed at establishing the discriminant validity of the
17 association between *M* responses and mirroring activity.
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21 **Hypothesis 2: Subtypes of M.** We anticipated that adequately perceived human beings
22 in movement (i.e., *M* with Form Quality ordinary; *M/FQo*), active human movement (*Ma*),
23 and human movement associated with whole human figures (i.e., *M* with pure *H*; *M/PureH*)
24 would be more strongly associated with mu suppression than distorted or unusual perceptions
25 of human beings in movement (i.e., *M* with Form Quality minus or unusual; *M/FQ-/FQu*)³,
26 passive human movement (*Mp*), and human movement associated with non whole-human
27 figures as animals (*A*) or human details (*Hd*) only or human-like figures or details [*(H)* and
28 (*Hd*)] (*M/NonPureH*). Indeed, *M/FQo*, *Ma*, and *M/PureH* responses are considered to be
29 more adequate or enhanced types of *M* responses – and thus more desirable and optimal –
30 than *M/FQ-/FQu*, *Mp*, and *M/NonPureH* (see Table 2). To test this hypothesis, mu
31 suppression occurring during *M/FQo*, *Ma*, and *M/PureH* responses was compared,
32 respectively, to that occurring during *M/FQ-/FQu*, *Mp*, and *M/NonPureH*.
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47 Effect size estimates for within-subjects analysis of variance were determined with η^2
48 using the following standard criteria: small = .01 to .05, medium = .06 to .13, and large =
49 greater than .14 (Kittler, Menard, & Phillips, 2007).
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54 Results

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3 Rorschach response verbalizations were transcribed verbatim and coded according to
4 standard CS rules. Before analyzing the data, three of the authors (L.G., P.P. and L.P.), who
5 are experts well trained in the CS and have been using the CS in clinical and research settings
6 for many years (two of them for more than 10 years), reached 100% agreement for the
7 presence vs. the absence of human movement included in the data analyses. Furthermore,
8 intra-class correlations (ICC) for all the other determinants (color, shading, achromatic and
9 pure form determinants) and contents of interest (animal, human, and human-like contents)
10 showed good ($ICC > .60$) to excellent ($ICC > .74$) agreement.
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20 Participants who did not produce any response of the type specified in an analysis
21 were excluded from that specific analysis. The number of participants included in each
22 analysis is reported in Table 3.
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27 **Hypothesis 1: M vs. Other Determinants**

28 For each contrast, a two-way repeated-measures analysis of variance compared the
29 mean mu suppression using response type (presence vs. absence) and scalp location (C3, Cz,
30 and C4) as within-subject factors (Table 3).
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36 Pineda et al. (2011) reported that a significant main effect was obtained for *M*
37 response (Table 1, Category 1) ($F(1,23) = 18.76, p < .001$), with a large effect size ($\eta^2 = .17$).
38 The additional analyses performed for the current study investigated whether other variables
39 were associated with mu suppression as well. The main effect for human contents in the
40 absence of *M* responses (Table 1, Category 2) approached statistical significance ($F(1,22) =$
41 $4.12, p = .055$), with a medium effect size ($\eta^2 = .06$). None of the other main effects – i.e., the
42 main effects for non-human movements (Table 1, Category 3), color responses (Table 1,
43 Category 4, first row), shading or achromatic responses (Table 1, Category 4, second row),
44 and pure form responses (Table 1, Category 4, third row) – approached significance.
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None of the scalp location main effects were significant. For non-human movements (Table 1, Category 3) the interaction effect (scalp location x response) was significant, $F(2, 46) = 3.88, p = .028$, but effect size was very small, $\eta^2 < .01$, and marginal means analyses did not reveal any significant differences, $p \geq .13$. None of the various other interactions was significant.

Hypothesis 1 that *Ms* are the unique Rorschach responses specifically associated with mu suppression at central brain sites was therefore supported. This result provides evidence for the discriminant validity of the association between *M* responses and mirroring activity.

Hypothesis 2: Subtypes of M

Similar to the procedure followed to test Hypothesis 1, for each contrast, a two-way repeated-measures analysis of variance compared the mean mu suppression using *M* type (optimal [*M/FQo*, *Ma*, and *M/PureH*] vs. non-optimal [*M/FQ-/FQu*, *Mp*, and *M/NonPureH*]) and scalp location (C3, Cz, and C4) as within-subject factors.

The comparison between adequately perceived human movement (*M/FQo*) and distorted-unusually perceived human movement (*M/FQ-/FQu*) did not produce significant difference, $F(1,10) = 1.95, p = .193$. A significant main effect for response was observed, instead, for the comparison between mu suppression for active (*Ma*) vs. passive (*Mp*) human movement, $F(1,17) = 7.27, p = .015$, with a medium to large effect size ($\eta^2 = .13$). Finally, mu suppression for human movement associated with whole human figures (*M/PureH*) did not significantly differ from mu suppression for human movement associated with non-whole human figures (*M/NonPureH*), $F(1,16) = .30, p = .593$. Details for these contrasts are found in Table 3, lower part. None of the various scalp main effects or interactions was significant.

Hypothesis 2 that *M* responses associated with variables more closely related to social cognition rather than poor social competence would produce higher mu suppression was only partially confirmed, only for active movement (*Ma*).

Additional Analyses

To rule out the rival hypotheses that findings were due to phenomena like attention or visual processing, rather than to a mirroring activity, the 8–13 Hz frequency band activity from occipital sites was examined as well. Indeed, if findings at the central sites were not due to a mirroring activity effect, but just to a ‘global alpha-like desynchronization’, then similar patterns at both central and occipital sites would be expected.

The same analyses that led to significant or nearly significant results at central sites were implemented for posterior sites (scalp electrodes O1 and O2). That is, a series of 2 x 2 within-subject repeated measures ANOVAs (site x response) was tested, with the alpha-like suppression at posterior sites being the dependent variable, while the site (O1 vs. O2) and the presence vs. absence of a response (i.e., M, Ma, and Non-M H Content) comprised the factors. In line with the mirroring activity explanation, none of the several main effects nor interactions analyzed were significant.

Discussion

In two previous studies (Giromini et al., 2010; Pineda et al., 2011) we explored the hypothesis that *M* responses to the Rorschach stimuli were associated with neural mirroring activity in the brain detected by the suppression of mu wave to EEG. Theoretical, clinical as well as empirical literature (see Introduction) indicate that while delivering *M* responses, the subject is likely using higher-level psychological functions related to cognitive sophistication, imagination, creativity, field independence, ego strength, cognitive processing of inner feelings, social cognition, and empathy. Mirror neurons are premotor neurons that fire not only when the subject performs an action but also when the subject observes another subject performing an action. More important, the MNS is hypothesized to facilitate the understanding of the underlying intentions, thoughts, and feelings that motivate a given action, thus providing the neural basis for understanding self and others’ behaviors and states

of mind (Buccino et al., 2001; Rizzolatti et al., 2001; Umiltà et al., 2001). In our first explorative study (Giromini et al., 2010), by using a test-contrast-control experiment we found confirmation that *M* responses are associated with mirroring activity. This result indicates that even in the absence of actual moving stimuli, and in the presence of static visual stimuli as the Rorschach cards, the inner feeling of movement is sufficient to trigger MNS activity when the intention of the action is “projected” onto the perceived human figure. As this first study used only 4 Rorschach cards with the higher and the lower frequency of *M* responses, it was replicated in our second study (Pineda et al., 2011) where the Rorschach test was administered closer to the standard procedure and with more appropriate experimental conditions (larger sample size, control for baseline condition, longer period of EEG data collection).

In the present study we explored two specific hypotheses with the aim of providing clinicians with a stronger empirical basis for the clinical interpretation of human movement to the Rorschach test. More in detail, we aimed at establishing the discriminant validity of the association between *M* responses and mirroring activity, and at investigating the relationship between mu suppression and a number of subtypes of *M*.

In our first hypothesis, “M vs. Other Determinants”, we explored whether mu wave suppression to the EEG recording – a likely index of mirroring activity – occurs uniquely when *M*s are given and not when other kinds of Rorschach-based movement responses such as animal or inanimate movements, as well as other movement-unrelated responses such as color, shading, and pure form responses. Findings show that our first hypothesis was fully confirmed. A highly significant mu suppression, with a large effect size ($\eta^2 = .17$), occurred only when subjects delivered *M* responses and not when they described movement performed by an animal or an inanimate object, objects without any movement implication, or other features of the blots, such as color, shading or its shape. For the first time, evidence for the

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3 discriminant validity of the association between *M* responses and mirroring activity has been
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5 provided.

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7 As predicted by our first hypothesis, the internal representation of the feeling of
8 movement elicited by the static inkblot stimuli and expressed uniquely by the *M* responses
9 are suggestive of the concurrent mirroring activity. This conclusion is made robust by
10 controlling for multiple conditions. First and most important, no index of MNS activity has
11 been observed in other kinds of Rorschach responses, regardless of whether movement was
12 or was not involved in the response process. Second, the mu wave suppression indicated by
13 the absence of activity in the EEG 8-13 Hz frequency band was specific to central sites of the
14 brain corresponding to the MNS location, whereas mu suppression was not recorded at
15 occipital sites that were used as controls. Third, the attention of subjects was controlled
16 during the baseline condition when they were asked to engage in a continuous performance
17 task lasting 90 s (counting the number of times the screen turned color from blue to red).
18 Finally, a sufficient duration of EEG recording was collected which were constituted by a
19 total of 600 s for 20 responses.
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36 Since the origin of the test, the production of an *M* response to the Rorschach has been
37 thought to rely on identification process: Individuals identify themselves with other human
38 figures seen in the blot while ‘simulating’ the feeling of movement within themselves, as if
39 they moved themselves (Malmgren, 2000). We propose that this self-initiated “feeling of
40 movement”, internally perceived and cognitively processed by the subjects, constitutes a
41 powerful stimulus for MNS activity. Previous studies showed that the MNS is triggered by
42 perceptual stimuli in which actions were explicit (moving objects in video clips) or implicit
43 (still pictures which suggest movement) (Rizzolatti & Craighero, 2004). Conversely, our
44 results were obtained in response to static stimuli that offer to the observer only minimal,
45 ambiguous cues. The psychological process underlying the production of *M* responses closely
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3 resembles that of embodied simulation. It has been proposed that the human capacity to pre-
4 rationally make sense of actions, emotions and sensations of others depends on “embodied
5 simulation,” a functional mechanism through which the actions, emotions, or sensations we
6 see activate our own internal representations of body states, that are associated with these
7 social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or
8 sensation (Freedberg & Gallese, 2007). Based on the MNS process, Gallese (2001, 2003)
9 speculated that this “shared manifold hypothesis of intersubjectivity” allows us to recognize
10 other human beings who are similar to us. Accordingly, we argued (Giromini et al., 2010)
11 that this position is supported within the social cognition field, a broad concept that refers to
12 the cognitive and brain processes that subserve behavior in response to other individuals of
13 the same species (Adolphs, 1999). By the fact that the specifics, content, and attributions
14 ensconced in the *M* response that is the meaning made in the response, is produced by the
15 individual, such idiographic information may very well have special relevance to the
16 individual. Such an understanding has been assumed by Rorschach practitioners when
17 interpreting idiosyncratic *M* response content (Exner, 1969; Meyer et al., 2011; Piotrowski,
18 1957).

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38 Although the effect size for *M* and mu suppression was considerably larger compared
39 to effect sizes for mu suppression and other Rorschach determinants, two cautions should be
40 expressed. First, the sample size was rather small ($N = 24$), and for some variables we only
41 had a few observations per subject, as indicated by the low mean values reported in table 1.
42 This is certainly a limiting factor for this study, in terms of both power and sensitivity of
43 these analyses, so that our findings need to be confirmed on larger samples. Second,
44 responses involving human beings who were not seen in movement (Non-*M H* Contents;
45 Table 1, Category 2) showed a medium effect size ($\eta^2 = .06$), and approached statistical
46 significance ($p = .055$). According to Exner (2003) the production of human content
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3 responses *per se* (i.e., regardless of the presence or absence of movement) to the Rorschach
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5 provides information about a facet of social competence related to the subject's interest in
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7 people, as "persons with considerable interest in others, for any of a variety of reasons,
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9 typically give several human content responses" (Exner, 2003, p.497). Future studies, with
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11 larger samples, might therefore investigate a possible association of mirroring activity and
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13 human contents to the Rorschach regardless of movement involvement.
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17 In our second hypothesis, "Subtypes of M," we explored whether mu wave
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19 suppression occurs more frequently to Rorschach codes thought to be more closely related to
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21 social cognition (adequately perceived whole human beings in active movement, i.e. *M*
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23 responses associated with ordinary Form Quality or *FQo*, active movement or *Ma*, and whole
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25 human figures or Pure *H*) rather than human movements more related to poor social cognition
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27 (i.e., *M* responses associated with distorted or infrequent Form Quality or *FQ-/FQu*, passive
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29 movement or *Mp*, and partial or fictional human figures or non-Pure *H*). Findings show that
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31 our second hypothesis was confirmed in part.
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35 As expected, among the various specifications of human movement, active movement
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37 (*Ma*) was found to significantly associate with greater mu suppression compared to passive
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39 movement (*Mp*). The raw mean value of -.30 observed for *Ma* in our sample was the highest
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41 mu suppression value among all the responses we investigated (see Table 3). In the CS, the
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43 active-to-passive *M* ratio is worthy of clinical attention when *Mp* is greater than *Ma*,
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45 reflecting a passive and possibly dependent interpersonal style and the subject is "more likely
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47 to take flight into passive forms of fantasy as a defensive maneuvers, and [is] less likely to
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49 initiate decisions or behaviors if the alternative that others will do so is available" (Exner,
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51 2003, p.439). As a consequence, because *Mp* is less frequent and reflects a more problematic
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53 and less desirable type of response than *Ma*, *Mp* generally receives greater interpretive
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55 attention than *Ma* in the clinical context. Our findings suggest that the relevance of *Ma*
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3 responses may be underestimated among clinicians. Indeed, according to our data, *Ma*
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5 responses might actually reveal important information in terms of social cognition and social
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7 competence resources because seeing active human movements in the Rorschach cards might
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9 likely trigger mirroring activity and therefore indicate more ability to identify with other
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11 human beings and competence in social cognition.
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14 Another prediction of this study concerned the form quality of the *M* response. The
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16 presence of good quality *Ms* is, in fact, a positive prognostic indicator, and *M* responses
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18 associated with distorted form quality may reflect disturbed thinking (Exner, 2003).
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20 Accordingly, we expected higher mu suppression for adequate vs. distorted perceptions of
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22 human beings in movement. Instead, no differences were found. However, it should be
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24 pointed out that – although non-significant – the observed mu suppression for *M/FQo* was
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26 higher than mu suppression for *M/FQ-/FQu*. Given that the effect size of this main effect was
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28 medium ($\eta^2 = .08$) and that the sample size of this analysis was small ($N = 11$), with a greater
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30 sample size such a difference might be significant. Thus, more research is needed to
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32 disentangle whether adequately perceived human movement (*M/FQo*) are more associated
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34 with mu suppression than distorted-unusually perceived human movement (*M/FQ-/FQu*).
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39 Finally, we anticipated that mu suppression for *M* associated with whole human
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41 figures (pure *H*) would be greater than mu suppression for *M* associated with non-whole
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43 human figures (non-pure *H*). Pure *H* is the only content coding category used for responses
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45 that include whole real people whereas human details and human-like figures refer to partial
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47 human body and fictional people. Whole human contents are therefore more common among
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49 individuals whose self-image is based more on identifications with real persons while non-
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51 whole human figures are more common among those whose self-image is based more on
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53 imagination or internal representations that coincide less with reality. Put simply, whole
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55 human contents reflect more accurate, integrated, and complete view of people than human
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3 details and human-like figures (Exner, 2003; Weiner, 2003). Findings do not support our
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5 second hypothesis. However, it may be worthy to note that this result may have been
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7 influenced by the fact that 18 of 31 (41.9%) *Ms* with non-pure *H* consisted of “face”
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9 responses (e.g., Card VII: “faces of children talking to each other”). It has been suggested
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11 that face stimuli are processed differently than other types of visual information because of
12
13 their evolutionary and interpersonal value (e.g., de Haan & Nelson, 1999; McCarthy, Puce,
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15 Gore & Allison, 1997; Meyer et al., 2011), so that they may actually reveal awareness of, or
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17 interest in, other people. Because of the very small number of subjects included in this sub-
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19 group, we were not able to run a comparison analysis to disentangle the specific role of
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21 “face” responses. This hypothesis paves the way for further Rorschach research in this
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23 direction.
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28 Some limitations of this study that prevent generalizing the results should be
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30 mentioned. First, for some variables only a few observations per subject were available, and
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32 the sample size consisted of a small number of undergraduate students, mostly women, with a
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34 rather homogeneous cultural background and a limited age range. The results should
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36 therefore be confirmed with a larger and more heterogeneous sample. Second, this study
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38 sought to quantify within-subject differences in μ suppression related to different response
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40 processes, but did not investigate any between-subject differences, because of the limited
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42 sample size. According to power analysis, indeed, between-subject comparisons require
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44 about three times the sample size required for within-subject comparisons. Future studies
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46 with larger sample sizes, therefore, should attempt to compare different groups selected on
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48 the basis of their Rorschach profiles. For example, it will be important to test the μ
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50 suppression phenomenon among those subjects who show $M_p > M_a$, those who show
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52 $H < [(H) + Hd + (Hd)]$, and so forth. Third, in this study we investigated the impact of form
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54 quality on μ suppression by comparing M/FQ_o vs. $M/FQ_-/FQ_u$. That is, we combined the
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MIRRORING ACTIVITY AND RORSCHACH TEST

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3 M/FQ- response with the M/FQu response, because too few EEG data were available for the
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5 M/FQ- response alone. However, for theoretical reasons (Exner, 2003; Meyer et al., 2011), a
6
7 better test of this contrast would probably be to look at the M/FQ- response alone vs. M/FQu
8
9 or M/FQo. Future studies should attempt to further investigate this issue. Similarly, future
10
11 research should also evaluate the infrequent but clinically relevant good Ms embedded in
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13 pathological responses (Level 2 Cognitive Special Scores, ALOG or CONTAM), which were
14
15 not analyzed in this study, again due to the limited amount of available EEG data. Fourth,
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17 participants were not screened for the presence of psychopathology or influencing level of
18
19 psychological distress. Evidence suggests that the number of *M* responses is associated to
20
21 specific personality functioning such as alexithymia (Porcelli & Meyer, 2002; Porcelli &
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23 Mihura, 2010) and the quality of *Ms* to psychopathology (Mihura, Meyer, Dumitrascu, &
24
25 Bombel, in press) and DSM-IV-defined personality disorders (Huprich, 2006). The
26
27 association of *M* and MNS activity should be further investigated on clinical samples to
28
29 evaluate the specific role played by psychopathological syndromes. Finally, although mu
30
31 wave suppression is considered a valid index of mirroring activity (Cochin et al., 1998;
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33 Muthukumaraswamy & Johnson, 2004; Oberman, McCleery et al., 2007; Oberman, Pineda et
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35 al., 2007; Pineda et al., 2000; Pizzamiglio et al., 2005; Rizzolatti et al., 2001), owing to the
36
37 low spatial resolution of EEG it is difficult to differentiate between activity selective to the
38
39 premotor MNS and activity in other regions that are part of a larger action
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41 observation/execution network that may modulate the activity in the premotor MNS
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43 (Muthukumaraswamy & Johnson, 2004; Muthukumaraswamy et al., 2004). Further
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45 investigations with higher-spatial-resolution techniques, such as functional magnetic
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47 resonance imaging and high-resolution EEG, may be able to dissociate between these two
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49 sources of activation.
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3 In conclusion, for the first time to our knowledge, this and our previous investigations
4 (Giromini et al., 2010; Pineda et al., 2011) show that Rorschach *M* responses are based on a
5 neurobiological ground indexed by the activation of mirror neurons. This overall result is
6 fully consistent with the century-long tradition of the Rorschach theoretical, as well as
7 empirical, literature. Two main conclusions can be drawn from these findings. First, mu
8 suppression specifically occurred for human movement responses (*M*) and did not occur for
9 any Rorschach responses involving movement (*FM* and *m*). Thus this type of suppression
10 seems to underlie MNS activation, suggesting a neurobiological basis for the clinical
11 interpretation of *M* determinant related to empathy and social cognition, supporting
12 theoretical speculations and clinical data. Second, future research should explore further and
13 address the likely clinical utility of active human movement (*Ma*) as the present study
14 suggests it is more closely related to the MNS activity than other movement-related
15 Rorschach scores. Also, from a broader perspective, one might speculate that the view of *M*
16 as index of higher psychological functioning and social cognition is consistent with historical
17 and contemporary theoretical models. For example, Piotrowski (1957) speculated that *M*
18 indicates basic ‘role-in-life’, deeply embedded in the subject’s ego, to assume stable attitudes
19 when relating to significant others. In his view, *M* is not a definite self-image but stems from
20 the integration of past and current representations of self and others that are implicit in the
21 subject’s behavior as potential underlying correlates. Thus, acting inconsistently with one’s
22 conception of role causes anxiety and distress. Contemporary models of mind highlight the
23 close link between individual and relational activity within the brain. For example, Damasio
24 (1999) referred to embodied cognition as the ability of the brain in simulation mode to
25 reproduce actual somatic states when emotions are induced not by observing others but also
26 by only feeling them in mind, and Fonagy, Gergely, Jurist, and Target (2002) to the construct
27 of mentalization as the individual ability to make and use symbolic representations of one’s
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own and the other's mental states. Given the importance of these constructs in clinical practice and psychological treatment (Allen, Fonagy, & Bateman, 2008), the association of *M* to the mirroring activity may shed new lights in Rorschach clinical interpretation.

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MIRRORING ACTIVITY AND RORSCHACH TEST

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Table 1.

Codes Included in the Analysis of Hypothesis 1 and their Descriptive Statistics

<i>Category & Label</i>	<i>Description</i>	<i>Code</i>	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>SD</i>
1) Human movement responses	Any human movement [<i>M</i>]	<i>M</i>	1	9	4.3	2.2
2) Non-moving human content responses	Whole [<i>H</i>], partial [<i>Hd</i>], or human-like [<i>(H)</i> , (<i>Hd</i>)] figures that are seen as non-moving	Non- <i>M</i> <i>H</i> Contents	0	7	2.8	1.8
3) Non-human movement responses	Animal movement determinant [<i>FM</i>] or inanimate movement determinant [<i>m</i>]	<i>FM/m</i>	1	9	4.9	2.3
4) Other Rorschach determinants	Any color determinant [<i>FC</i> , <i>CF</i> , <i>pure C</i>]	<i>C</i>	0	14	4.7	3.6
	Any shading determinant including diffuse shading [<i>FY</i> , <i>YF</i> , <i>Y</i>], texture [<i>FT</i> , <i>TF</i> , <i>T</i>], tri-dimensional [<i>FV</i> , <i>VF</i> , <i>V</i> , <i>FD</i>], and achromatic color [<i>FC'</i> , <i>C'F</i> , <i>C'</i>]	Shading	0	6	3.0	1.6
	Responses based exclusively on the shape of the blot [<i>F</i>]	<i>F</i>	1	15	7.3	2.9

Note: In the Comprehensive System, animals that are seen in non species-specific kind of movement are coded *M* as for the determinant (implying the use of fantasizing activity) and *A* as content (e.g., “an ant dancing rock ‘n’ roll”)

MIRRORING ACTIVITY AND RORSCHACH TEST

Table 2.

Codes Included in the Analysis of Hypothesis 2 and their Descriptive Statistics

Optimal Type of M						Non-Optimal Type of M					
Label & Code	Description	Min	Max	M	SD	Label & Code	Description	Min	Max	M	SD
Adequate perception of human movement (M/FQo)	Human movement [M] associated to Form Quality ordinary [FQo]	1	8	3.4	1.9	Distorted or unusual perception of human movement (M/FQ-/FQu)	Human movement [M] associated to Form Quality minus [FQ-] or Form Quality unusual [FQu]	0	4	.9	1.1
Active human movement (Ma)	Human movement [M] associated to activity [Ma]	0	5	2.2	1.6	Passive human movement (Mp)	Human movement [M] associated to passivity [Mp]	0	8	2.1	1.7
Human movement associated with whole human figures (M/PureH)	Human movement [M] associated to whole human figure [H]	0	7	2.9	1.9	Human movement associated with non whole human figures (M/NonPureH)	Human movement [M] associated to content categories of animals [A], human details [Hd], and human-like figures or details [(H), (Hd)]	0	3	1.3	1.1

MIRRORING ACTIVITY AND RORSCHACH TEST

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Table 3.

Main Effect on Mu Suppression for the Rorschach Responses Under Investigation

	Mu Suppression for Presence of Response			Mu Suppression for Absence of Response		Main Effect for Response (Presence vs. Absence)			
	<i>N</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>F</i>	<i>df</i>	<i>p</i>	η^2
Hypothesis 1 (<i>M</i> vs. Other Determinants)									
Human Movement Responses (<i>M</i>)	24	-.24	.05	-.17	.05	18.76	1,23	.000	.17
Non-Moving Human Contents (Non- <i>M H</i> Contents) ^a	23	-.19	.06	-.15	.05	4.12	1,22	.055	.06
Non-Human Movement Responses (<i>FM/m</i>)	24	-.17	.06	-.18	.05	.13	1,23	.718	<.01
Color Responses (<i>C</i>)	22	-.17	.06	-.16	.05	.01	1,21	.930	<.01
Shading Responses (Shading)	23	-.16	.06	-.19	.05	2.12	1,22	.160	.03
Pure Form Responses (<i>F</i>)	24	-.17	.07	-.19	.05	.86	1,23	.362	.01
Hypothesis 2 (Subtypes of <i>M</i>)^b	<i>N</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>F</i>	<i>df</i>	<i>p</i>	η^2
Adequately (<i>M/FQo</i>) perceived <i>M</i> responses	17	-.20	.06	-.13	.07	1.95	1,10	.193	.08
Active (<i>Ma</i>) <i>M</i> responses	18	-.30	.07	-.21	.05	7.27	1,17	.015	.13
<i>M</i> associated with whole human figures (<i>M/PureH</i>)	11	-.25	.06	-.28	.05	.30	1,16	.593	.01

Notes: ^a Given that it is likely that *M* responses occur along with human contents, to avoid confounds this contrast was tested after excluding all *M* responses from the analysis; ^b Only *M* responses are considered for this analysis; absence of *M/FQo*, *Ma*, and *M/PureH* responses, therefore, indicates – respectively – presence of *M/FQo*–*FQu*, *Mp*, and *M/NonPureH* responses.

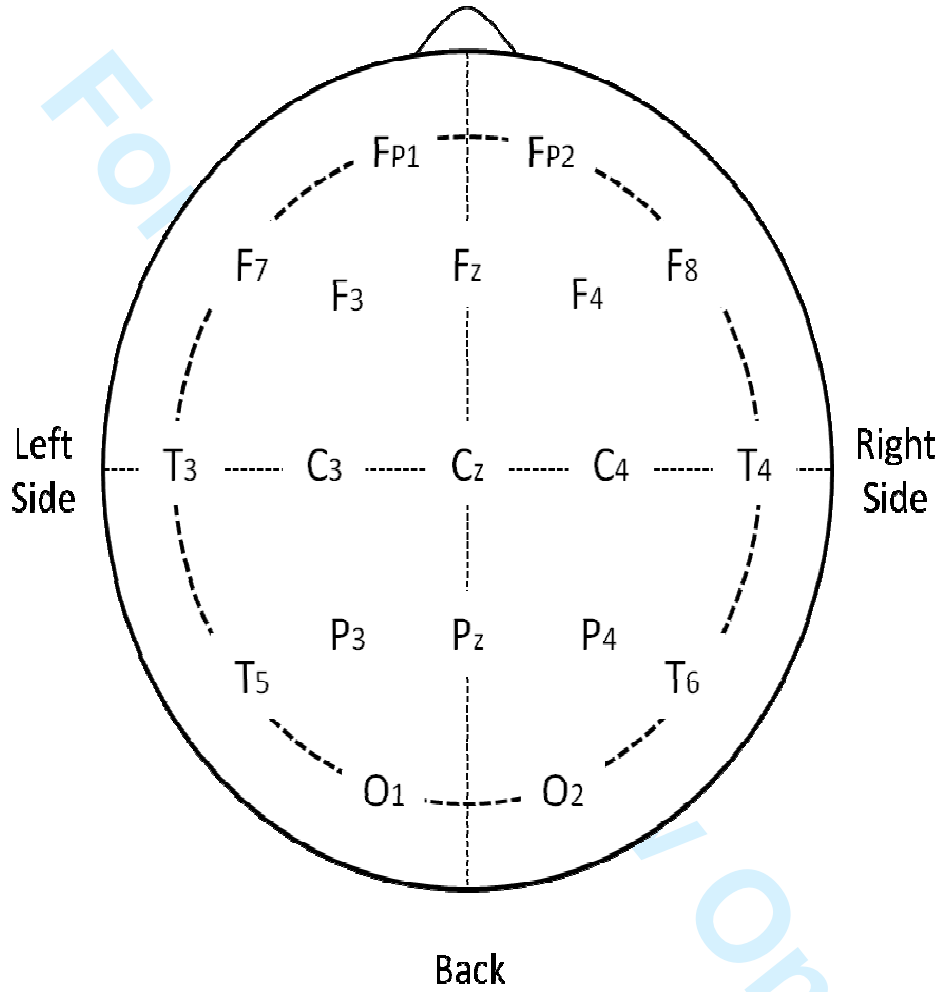
Figure Caption

Figure 1.

Map of the EEG scalp locations.

Note: According to the International 10-20 system method, each site has a letter to identify the lobe and a number to identify the hemisphere location. As for the letters, F stands for frontal, T for temporal, P for parietal, and O for occipital. Although there exists no central lobe, a letter C is also used, for identification purpose, and stands for central. As for the numbers, odd numbers refer to locations in the left hemisphere, and even numbers refer to locations in the right hemisphere; the letter z stands for zero and refers to the midline.

Figure 1



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Footnotes

¹Although the word ‘kinesthesia’ in the Rorschach literature is often adopted with the original meaning given by Rorschach, it should be noted that this term may be labeled within the neurocognitive science field as kinesthetic identification, mimicking or simulating.

²The term “social cognition” is often used interchangeably with terms such as “theory of mind” and “social perception.” Originally coined by Premack and Woodruff in 1978, theory of mind involves the ability to understand and identify others’ mental states. In a related way social perception, introduced by Bruner in 1947, refers to forming impressions and making inferences about other people’s intentions. Here, we broadly refer to “social cognition” as the cognitive and brain processes that subserve behavior with other people (Adolphs, 1999). From this perspective, it subsumes both theory of mind and social perception.

³ We combined the M/FQ- response with the M/FQu response, because too few EEG data were available for the M with FQ- response alone. Indeed, only six individuals produced M/FQ- responses, and three of them produced only one M/FQ-