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Only an inkblot? A literature review of the neural correlates of the Rorschach inkblot test

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ABSTRACT

The Rorschach inkblot test allows access to psychological processes that usually do not emerge in self-report measures and it has been widely used in clinical psychological and psychiatric settings. Recordings of brain activity during the administration of the Rorschach inkblots test could provide information on neural correlates of the underlying perceptual-cognitive processing and potentially identify neuroimaging markers of psychopathology risk. The present paper offers a systematization of the available literature on the Rorschach inkblot test and neuroimaging research. The 13 selected studies had been conducted with healthy participants and using fMRI, EEG, and fNIRS to investigate the neural underpinnings of Rorschach inkblot test responses. The neural processes underlying the visual, social, and emotional processes described by the included papers are systematically summarized. Research on the neural correlates of the Rorschach inkblot test is promising and would further benefit from studies on clinical populations, broader samples, and younger age groups.

The Rorschach inkblot test (Rorschach, 1921) is a well-known and widely used test that, after decades of inaccurate classifications, is currently defined as a stimulus-attribution task (Camara et al., 2000; Cook et al., 2017; Meyer and Kurtz, 2006; Ready and Veague, 2014; Wright et al., 2017). It consists in showing subjects a series of 10 ambiguous and symmetric inkblots and asking them to tell the examiner what each inkblot could be. The inkblots differ in shape and color: five are achromatic, three are fully colored (VIII, IX, and X), and two are both achromatic and chromatic (II and III). Administration consists of two phases: (1) spontaneous response production and (2) clarification by the examiner. When all responses have been collected and investigated, the examiner codes and interprets them based on features such as the theme of the response (e.g., aggressive content or cooperation), the position where the subjects reported seeing something, and which element of the inkblot elicited that response. Other factors that account for the interpretation are the perceptual determinants of the response, and any comment the subjects give concerning a specific inkblot in the clarification phase.

Hermann Rorschach published *Psychodiagnostics*, his only book, in 1921 (Rorschach, 1921), one year before dying, after a decade of research on creativity, various types of intelligence and mental disorders, and projects related to his curiosity for art and drawings. It seems that his experiments began with a study of inkblots made by adolescents aged 12–16 years, students of his teacher friend, what they had seen and what part of the inkblot they had seen it in. He used those preliminary findings to investigate perception and apperception in healthy and ill people, discovering unexpectedly that his empirical results could be used as an assessment tool for making diagnoses, measuring intelligence, and characterizing different types of pathology, starting with schizophrenia (Keddy et al., 2021).

From the first development of the test in 1921 to the present days, various systems and methods of administration and coding have been developed. These include the Exner Comprehensive System (CS) (Exner, 2003; Exner et al., 2022; Meyer et al., 2002) and the Rorschach Performance Assessment System (R-PAS) (Meyer, 2011; Meyer and Eblin, 2012; Pianowski et al., 2021). From the earliest days, exponents of different Rorschach interpretation methodologies have fueled a debate about several aspects of the test. The diatribe between supporters of the

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R-PAS, the most psychometrically advanced system, and its detractors, still tied to coding according to the CS, is well known. The disagreement, which has been going on for years now, recently led to the publication of a study that distrusts the use of the CS and the other not improved coding systems in the legal field (Viglione et al., 2022). Some of the criticisms directed at the R-PAS are given below. The first of these controversies is test validity, i.e., to confirm that the test measures what it wants to measure (Cronbach, 1949; Lilienfeld et al., 2000; Meyer, 2004; Meyer and Archer, 2001). Several authors confirmed that the Rorschach inkblots test could add essential data to the evaluation of personality and cognitive and perceptual processes (Meyer, 2017; Mihura et al., 2013). Recently, a comparison of 53 meta-analyses examining variables against externally assessed criteria (e.g., observer ratings, psychiatric diagnosis) confirmed good test validity and that the variables that consider cognitive and perceptual processes (e.g., Perceptual-Thinking Index, Synthesized Response) have high evidence-based support (Mihura et al., 2013). The second controversy pertains interrater reliability, i.e., the fact that two or more independent coders agree on what to code, that do not rely on the examiner's expertise, as recent research demonstrated (Lewey et al., 2019; Pignolo et al., 2017; Viglione et al., 2012). Additionally, concerns have been raised also for a plausible ethnicity bias, i.e., the risk of penalizing and not adequately considering minorities. However, recent works highlighted how Rorschach scores are not influenced by ethnicity, gender, age, and education, so that minorities underrepresentation does not seem to be a credible issue (Meyer et al., 2015). Finally, the representativeness of the normative data was discussed, i.e., that the reference values represent the normative population and not a model population with performance trending toward the upper limits of the mean. Empirical evidence has strongly supported this point (Giromini et al., 2015).

The complex and ambiguous inkblots, still used in clinical, legal, and research practice today, require effort from the subject to visualize and name the evoked image. Therefore, although there are more and less popular responses to Rorschach inkblots, each person brings their unique contribution: responses are considered informative about the individuals themselves, their thoughts and personalities, and their way of forming predictions on the world and relationships with other people (Meyer and Friston, 2022). While describing the Rorschach inkblots, patients can communicate images that access psychological processes that usually do not emerge in self-report measures (Kaser-Boyd, 2021). This instrument has also been used for trauma assessment, personality assessment (i.e., coping style, emotions, managing stress, mediation, ideation, self-perception, interpersonal relationships), and diagnostic evaluations in psychiatric disorders such as schizophrenia (Mondal and Kumar, 2021).

While schizophrenia is associated mainly with thought/ideation disorders and low perceptual accuracy or internalization of affect (Mason et al., 1985), the Rorschach test can explore other dimensions linked to other psychopathological conditions. For instance, when studying psychopathological disorders, personality, behavior, and cognition, special interest is in the biological basis of functioning and neural processes (Banich et al., 2009; Perkins et al., 2020; Sydnor et al., 2021). In recent years, Rorschach inkblots have been variously used in neuroimaging studies (Jimura et al., 2021). On the one hand, inkblots represent complex and ambiguous stimuli beneficial for studying brain functions such as visual perception and language production. On the other hand, recording brain activity during the administration phase could provide evidence for the neurobiological foundation of Rorschach indexes, shedding light on the validity of the test itself and at least partially bridging the gap between neuroscience and psychopathology fields.

Nonetheless, empirical evidence on neural activation in response to the different dimensions is still limited (Jimura et al., 2021; Muzio, 2016). A systematization of such research might help shed light on what is already known, what needs to be further explored, and the clinical utility of the findings. In the present work, we review the literature and describe the state of the art of the Rorschach test and neuroimaging.

1. Methods

We interrogated the PubMed database in May 2022 with the following keywords: for functional Magnetic Resonance Imaging (fMRI) studies: (("neuroimaging") OR ("neuroscience") OR ("neural activity") OR ("fMRI")) AND ("Rorschach"); for electroencephalographic (EEG) and functional Near Infrared Spectroscopy (fNIRS) studies: (("Functional near-infrared spectroscopy") OR ("fNIRS") OR ("electroencephalography") OR ("EEG")) AND ("Rorschach"); for PET/CT studies: (("Positron Emission Tomography") OR ("PET") OR (" computed tomography") OR ("CT")) AND ("Rorschach"). We filtered the results by the time of publication (i.e., excluding papers published before 1990), species (i.e., excluding studies that were not conducted with humans), and language (i.e., excluding papers published in a language other than English).

The abstracts identified by the search were examined with support of the Rayyan (http://rayyan.qcri.org) platform to check their suitability to our work. Then, agreement among independent coders was achieved and – when needed – solved by confrontation. From this initial step, we retrieved 47 papers. Moreover, one publication was added by cross-referencing. We excluded 4 papers because we could not recover the full text. The next step was the analysis of n = 44 full-text records. Pertinent abstracted data included: the brain areas detected, the focus of the Rorschach (e.g., as a whole or on a specific response), and the population in which it was used. From the information gathered, we excluded 4 records because they did not use the Rorschach test, 5 because their focus was on speech/language (i.e., the Rorschach responses were analyzed as a sample of a non-specific text rather than as a source of stimulus-attribution material), and 22 records because they did not use any of the neuroimaging techniques of pertinence for this systematic review. The final set of records included 13 original papers.

2. Results

2.1. Participants included in the studies

Among the 13 included studies, the age of the participants varied from 13 to 36 years, and most studies recruited adult subjects (see Table 1); the experimental sample size varied from 18 to 68 subjects. All participants were healthy subjects (i.e., did not have any psychopathological symptoms or full-blown mental disorders).

2.2. Manipulations of the standard Rorschach administration

The experimental stimuli, settings, and tasks differed among the papers. All studies used Rorschach inkblots as stimuli to elicit a neural response; however, some used the whole set of 10 inkblots, while others selected a specific subset according to the response they wanted to investigate.

2.3. Manipulation of administration procedures

The setting varied according to the neuroimaging tool used. However, participants in all studies except two (Asari et al., 2008; Mazhirina et al., 2020) were instructed not to move or talk during the inkblots presentation, only focusing on thinking about what they might be; after the acquisition of the neuroimaging data, they were asked to verbalize their responses. In a study, participants were asked to press a button when they came up with a response. In two studies, participants were asked to verbalize their responses during registration (Asari et al., 2008); in another study, they were asked first to observe inkblots and other tables and then to identify a meaningful name for each of them (Mazhirina et al., 2020).

Table 1
Summary of the included studies.

Study	Technique	Brain regions and networks detected	Processing domain	Coding system	Rorschach cards used	Focus on a specific Rorschach response	Age in years (mean ± SD [age range])	Number of subjects
Asari et al. (2008)	fMRI	Right temporal pole	Perception-emotion linkage	None	I-X	Unique perception	experimental: 25.1 ± 4.6 [20–36]; control: 23.3 ± 3.5 [20–39]	68 experimental group, 217 control group
Ishibashi et al. (2016)	fMRI	Bilateral visual areas, parieto-occipital junctions, pulvinar, right superior temporal gyrus, left premotor cortex (achromatic inkblots); left visual area, left orbitofrontal cortex (chromatic inkblots)	Visual processing; chromatic versus achromatic inkblots	None	I-X	No	24.7 ± 4.8 [17–28]	40
Giromini et al. (2017)	fMRI	Temporo-occipital and fronto-parietal regions; sub-cortical regions included in the limbic system	Complex visual processing; fronto-parietal attentional pathways	None	I-X	No	21.4 ± 2.3 [17–28]	26
Giromini et al. (2019)	fMRI	Mirror neuron system	Motion processing	R-PAS	I-X	Human movement (M)	21.4 ± 2.3 [17–28]	26
Giromini et al. (2019)	fMRI	Cortical and subcortical reward system regiorns (e.g., nucleus accumbens, caudate nucleus). Motor and premotor areas	Reward system; language and mouth movement areas	R-PAS	I-X	Oral dependent language (ODL)	21.4 ± 2.3 [17–28]	26
Mazhirina et al. (2020)	fMRI	Frontal cortex, parietal associative region (precuneus), occipital visual region, cerebellum	Ambiguity tolerance; visual processing	None	I-X	No (tables of Rorschach containing ambiguity)	23 ± 3 [22–26]	18
Vitolo et al. (2021)	fMRI	Intraparietal sulcus, precuneus, posterior cingulate cortex, supplementary eye fields, frontal eye fields	Dorsal Attention Network (DAN)	R-PAS	I-X	More complex Rorschach responses	21.4 ± 2.3 [17–28]	26
Hiraishi et al. (2012)	fNIRS	Bilateral prefrontal cortex	Social brain network and semantic representations of stored visual information	None	I-X	No	13.8 ± 0.8 [n.a.]	17
Ando' et al. (2018)	EEG	Left inferior gyrus vs Vertex (control)	Motion processing	R-PAS	Cards II, III, and VII	Human movement (M)	Experimental: 20.61 ± 0.98 [19–23]; control: 21.67 ± 3.18 [19–33]	15 experimental group, 13 control group
Luciani et al. (2014)	EEG	Left primary somatosensory cortex; frontal and parietal areas	Motion processing; meaning attribution to visual stimuli	None	I-X	Structured vs non structured figures	25.15 ± 6.3 [n.a.]	20
Giromini et al. (2010)	EEG	Mirror neuron system	Motion processing	RCS	Cards III and VII (highest frequency of human movement attribution) and cards V and VI (lowest frequency of human movement)	Human movement (M)	20.58 ± 1.98 [18–27]	19
Pineda et al. (2011)	EEG	Mirror neuron system	Motion processing	RCS	I-X	Human movement (M)	20.4 ± 1.9 [18–25]	24
Porcelli et al. (2013)	EEG	Mirror neuron system	Motion processing	RCS	I-X	Human movement (M)	20.4 ± 1.9 [18–25]	24

Note. Techniques: fMRI - functional Magnetic Resonance Imaging; fNIRS – functional Near Infrared Spectroscopy; EEG – Electroencephalography. Coding systems: R-PAS - Rorschach Performance Assessment System; RCS - Rorschach Comprehensive System.

2.4. Neuroimaging methodology

Among the studies included, 8 used fMRI, 5 EEG, and 1 fNIRS, while none used PET or CT. All papers recorded a baseline neural activity or the neural activity while looking at a fixation cross to highlight differences with the inkblots condition among the same group of participants; not all studies used a control task or a control group.

2.5. Neuroimaging analytical targets

Statistical analyses differed between papers: in some studies, they were performed globally on the whole brain, while in others, they were restricted to specific brain areas due to the selection of regions of interest (ROI) or to the constraints of the technique used (e.g., fNIRS to some of the sources).

Contrasts were performed according to the research question; for example, a study investigated the differences in neural activity in response to chromatic versus achromatic Rorschach inkblots. Others wanted to detect brain activity when the subject was giving a specific response. In the following sections, we will describe the main results observed through fMRI, EEG, and fNIRS from the included records.

2.6. Main findings: fMRI

In 5 studies, fMRI data were collected while participants performed the Rorschach task. A study conducted with 26 healthy participants found temporo-occipital and fronto-parietal activations, with greater activity in some small, sub-cortical regions in the limbic system (Giromini et al., 2017). Another study conducted on the same sample found activation in an EEG signal that presumably associates with activity in the mirror neuron system (from now referred to as MNS) when focusing on the "human movement" (M) index – i.e., when subjects attributed a typically human movement to what they saw in the inkblot (Giromini et al., 2019). In a further study conducted by the same research group, activation was found in cortical and subcortical regions involved in the reward system (e.g., nucleus accumbens, caudate head, and others) when focusing on the keyword "dependence" (referred to the ODL index), and in motor and premotor areas involved in various functions associated with language and the movement of the mouth when focusing on the keyword "oral" (referred to the ODL index) (Giromini et al., 2019). Moreover, a study found activation in the Dorsal Attention Network (DAN) when focusing on highly complex responses (Vitolo et al., 2021). Finally, a study conducted in Japan found activation in the right temporal pole when focusing on very infrequent (unique) responses (Asari et al., 2008).

Two studies used fMRI to detect activation or deactivation in the brain when participants were observing Rorschach inkblots. A study conducted on 40 healthy participants found activation in bilateral visual areas V2 and V3, parieto-occipital junctions, pulvinars, right superior temporal gyrus, and left premotor cortex for achromatic color cards (Ishibashi et al., 2016), and left visual area V4 and left orbitofrontal cortex for the cards with chromatic color (Ishibashi et al., 2016). Another study conducted in Russia found an association between activation in the frontal cortex, parietal associative region (precuneus), occipital visual region, and cerebellum, and the subjective tolerance to ambiguity as a variable for data analyses (Mazhirina et al., 2020).

2.7. Main findings: EEG

Three studies that used EEG detected mu wave suppression over the sensorimotor cortex – the MNS, when focusing on "movement" (Giromini et al., 2010; Pineda et al., 2011; Porcelli et al., 2013).

EEG was also used combined with other techniques. A study recorded EEG while performing rTMS over the left inferior gyrus (LIFG) while participants observed Rorschach inkblots thinking of what they might be. It was found that disrupting the LIFG, but not Vertex, decreased the number of M attributions provided by the participants exposed to the Rorschach stimuli; however, rTMS did not significantly influence EEG mu suppression (Ando' et al., 2018).

Another study conducted in Italy recorded EEG and low-resolution electromagnetic tomography when observing Rorschach inkblots or gray polygonal shapes and thinking of what they might be to study stimulus-attribution mechanisms (Luciani et al., 2014). Source analyses showed a greater activated source in the left primary somatosensory cortex compared to all the other brain areas in both conditions through all the ERP components; moreover, involvement of the frontal and parietal areas was found while describing not-structured visual stimuli.

2.8. Main findings: (f)NIRS

A study investigated with fNIRS the neural activity related to three typical performance tests – namely, the Rorschach test, the Rosenzweig Picture-Frustration Study for children (PFS), and the Thematic Apperception Test (TAT) – used to assess a sample of adolescent participants (Hiraishi et al., 2012). Focusing on the rostral area of the prefrontal cortex (BA10), this study showed that completing the PFS activated the left prefrontal cortex significantly more than completing the Rorschach and TAT. At the same time, the TAT and Rorschach may be somewhat more right-hemisphere-dominant tasks, although each task requires a complex combination of right and left hemisphere activity. The authors suggested that the cause is related to sociality and emotion.

3. Discussion

While a few publications partially described research correlating responses to the Rorschach test with neuroimaging findings (Meyer and Friston, 2022; Muzio, 2016), no comprehensive literature review was available to date. With the present review, we aimed to summarize the evidence on neural activation in response to Rorschach inkblots. Our results indicate that only a few studies investigated this topic using neuroimaging techniques. When analyzing responses to the Rorschach test, social, linguistic, and emotional responses are, alongside visual perceptual processes, the main factors to be considered (Hiraishi et al., 2012). From the collected studies, we found a reflection of each of these dimensions regarding brain activity (Fig. 1).

First, the Rorschach test comprises a visual task. The temporo-occipital and posterior temporal gyrus activations suggest not a primary visual activation (which would be more purely occipital). Yet they denote more complex visual processing that seems to rely on the extrastriate cortex (Giromini et al., 2017; Ishibashi et al., 2016). Moreover, a positive personal attitude towards ambiguity is associated with increased response in the visual cortex when presenting ambiguous stimuli. At the same time, deactivation in the frontal areas and occipital-cerebellar regions is associated with increased focus on cognitive tasks (Mazhirina et al., 2020). Secondly, the involvement of attentional processes has been corroborated by detecting frontoparietal pathways (Giromini et al., 2017; Vitolo et al., 2021). The limbic system activation highlights underlying processing in the emotional and memory domains (Asari et al., 2008; Giromini et al., 2017). The prefrontal cortex (PFC), along with the superior temporal sulcus (STS) and the amygdala, is also part of the so-called social brain network. These areas are involved in the Rorschach stimuli processing as they have been found to support semantic representations of stored visual information (Hiraishi et al., 2012). Moreover, brain-related activity occurring during the Rorschach task can be comparable to the one happening in real life in response to the evoked Oral Dependent Language (ODL) images. The ODL is a variable that measures both the implicit and explicit psychological processes related to dependence and oral motives (Aschieri et al., 2021). For instance, responses in the oral domain are associated with motor and premotor activation, while responses in the dependency domain are meant to activate the reward system in the brain (Giromini et al., 2019). Finally, whenever human movement is an involved element, studies report activations in the MNS (Ando' et al., 2018; Giromini et al., 2010; Giromini et al., 2019; Luciani et al., 2014; Pineda et al., 2011; Porcelli et al., 2013). MNS activity has been observed during both movements' execution and observation and it has been hypothesized to represent the neurological substrate of a mirror-matching mechanism. Such a mechanism would allow individuals to quickly understand the actions performed by others just by observing (Gallese, 2013; Pineda, 2005; Rizzolatti and Craighero, 2004), a skill that seems to be available and active even in newborns (Quadrelli et al., 2019). Given the absence of explicit cues in the Rorschach stimuli, the studies that detect MNS activation support the idea that the internal sense of identification with human movement plays a central role in embodied

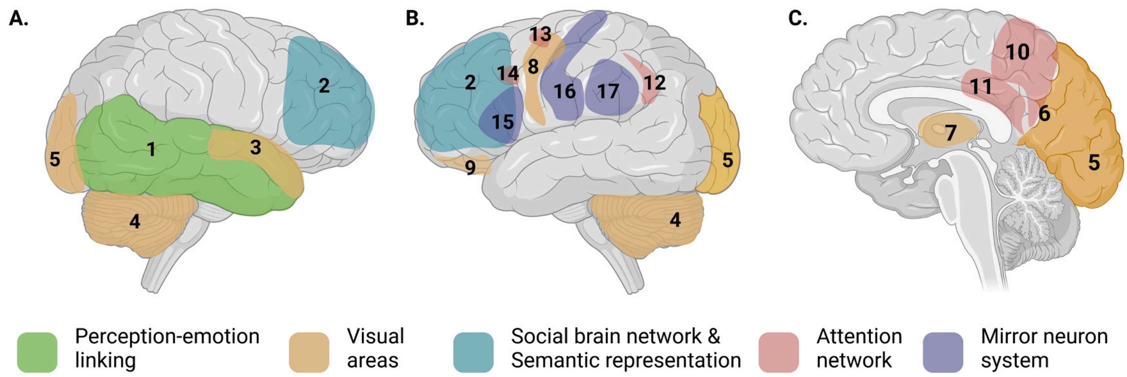

Fig. 1. Main areas described as being activated by the Rorschach test tasks employed in the reviewed studies. 1, Right temporal lobe; 2, Bilateral prefrontal cortex; 3, Right superior temporal gyrus; 4, Cerebellum; 5, Bilateral visual areas; 6, Parieto-occipital junction; 7, Pulvinar (thalamus); 8, Left premotor cortex; 9, Left orbitofrontal cortex; 10, Precuneus; 11, posterior cingulate cortex; 12, Intraparietal sulcus; 13, Supplementary eye fields; 14, Frontal eye fields; 15, Left inferior frontal gyrus; 16, Left primary motor cortex; 17. Inferior parietal lobule. Note. Created with BioRender.com. Publication license n. AD25GKLSKL.

simulation (Pineda et al., 2011).

While the picture drawn by this descriptive work is promising, we found some limitations throughout the search. Most of the articles included adult participants; only one study included adolescent participants of 13 years of age (Hiraishi et al., 2012). Thus, there is still a lack of information on younger subjects and how the neural response to Rorschach inkblots changes with growth. Moreover, all the papers in our review involved healthy participants, while research on the clinical population is still lacking. Some papers studied the responses patients with schizophrenia gave to the Rorschach test, but we excluded them because their aim was investigating language function and brain areas. Most of the papers had a limited number of participants. This limitation exacerbates because 4 out of 13 references examined the same sample, leading to the following observation: few labs are working on this topic, which may lead to limited information. At present, researchers that used Rorschach inkblots focused on perception or on the neural mechanisms underlying the Rorschach test itself and on specific Rorschach indexes such as "movement" or "dependency" (Meyer and Friston, 2022). Higher or more complex functions that can be classically derived from the Rorschach test, such as the representation of self and others, have not yet been investigated. For instance, only one study investigated creative thinking; however, this dimension was calculated as the frequency of the responses given by the subject (i.e., the less common, the more creative they were considered). Therefore, creativity per se was not considered. Yet, highly creative people have demonstrated elevated risk for psychopathology (Carson, 2011).

4. Conclusions

In the neuroscientific approach to psychopathology, we must consider that the biological determinants of risk often interact with higher cognitive functioning (Ilonen et al., 2016; Meyer, 2016). This interplay can actually result in protective and risk conditions for psychopathology (Carson, 2011; Hoorelbeke et al., 2019; Lynch et al., 2021). Obtaining information on the neural correlates of perceptual-cognitive and problem-solving processes undergoing the interpretation of the Rorschach inkblots might allow the detection of pathological links between the two. In this perspective, a more profound knowledge of brain activation in response to the different Rorschach inkblot test domains might also become a tool to better understand the psychopathological brain. All this suggests that the scientific community has an excellent opportunity to broaden the research on the Rorschach inkblot test by including clinical samples, different age groups, and a higher number of participants or analyzing activity related to other responses to the test.

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Declarations of interest

The authors report there are no relevant financial or non-financial competing interests to report.

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