AperTO - Archivio Istituzionale Open Access dell'Università di Torino

Neural activity during production of rorschach responses: An fMRI study

This is the author's manuscript

Original Citation:

Availability:

This version is available http://hdl.handle.net/2318/1635693 since 2017-05-17T17:42:59Z

Published version:

DOI:10.1016/j.pscychresns.2017.02.001

Terms of use:

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

25 April 2024

IRIS AperTO

UNIVERSITÀ DEGLI STUDI DI TORINO

This Accepted Author Manuscript (AAM) is copyrighted and published by Elsevier. It is posted here by agreement between Elsevier and the University of Turin. Changes resulting from the publishing process - such as editing, corrections, structural formatting, and other quality control mechanisms - may not be reflected in this version of the text. The definitive version of the text was subsequently published in PSYCHIATRY RESEARCH. NEUROIMAGING, 262, 2017, 10.1016/j.pscychresns.2017.02.001.

You may download, copy and otherwise use the AAM for non-commercial purposes provided that your license is limited by the following restrictions:

(1) You may use this AAM for non-commercial purposes only under the terms of the CC-BY-NC-ND license.

(2) The integrity of the work and identification of the author, copyright owner, and publisher must be preserved in any copy.

(3) You must attribute this AAM in the following format: Creative Commons BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/deed.en), 10.1016/j.pscychresns.2017.02.001

The publisher's version is available at:
http://linkinghub.elsevier.com/retrieve/pii/S0925492716302797

When citing, please refer to the published version.

Link to this full text:
http://hdl.handle.net/

This full text was downloaded from iris - AperTO: https://iris.unito.it/

iris - AperTO

University of Turin's Institutional Research Information System and Open Access Institutional Repository

ABSTRACT

Recently, a lot of effort has been made to ground Rorschach interpretations to their evidence base. To date, however, no studies have yet described, via fMRI, what brain areas get involved when one takes the Rorschach. To fill this gap in the literature, we administered the ten-inkblot stimuli to 26 healthy volunteers during fMRI. Analysis of BOLD signals revealed that, compared to fixating a cross, looking at the Rorschach inkblots while thinking of what they might be associated with higher temporo-occipital and fronto-parietal activations, and with greater activity in some small, sub-cortical regions included in the limbic system. These findings are in line with the traditional conceptualization of the test, as they suggest that taking the Rorschach involves (a) high-level visual processing, (b) top-down as well as bottom-up attentional processes, and (c) perception and processing of emotions and emotional memories.

Keywords: Rorschach; fMRI; Neural; R-PAS; Assessment.

Neural Activity during Production of Rorschach Responses: An fMRI Study

1. Introduction

The Rorschach (Rorschach, 1921) consists of a set of ten inkblot designs that the examinee views to answer the question "what might this be?" The examinee's imagery, visual attributions and descriptions are taken into account for formulating interpretations. Indeed, the Rorschach "provides a standardized, in vivo sample of problem-solving behavior that can be understood from multiple viewpoints, including: direct observation of task behavior; comparison of numerous dimensions of visual and verbal performance with normative expectations; and analysis of the content, imagery, and sequence of responses" (Meyer et al., 2011, p.1). Thus, for example, a tendency toward accounting for the entire blot when delivering a Rorschach response might reveal a propensity, in a person's daily life, to look at "the big picture" rather than to focus on small details. As another example, seeing in the inkblots numerous percepts or objects that are typically not seen by the nonclinical populations is likely to reflect a tendency to not see the world as others do, which in turn might reflect originality, unconventionality, or perhaps even atypical judgment or poor reality testing.

Understanding the psychological processes underlying the production of Rorschach responses is crucial for the Rorschach-based psychological assessment. Accordingly, recent advances in neuroimaging might offer a unique opportunity. For example, research findings suggest that individuals with anorexia nervosa (AN) and body dysmorphic disorder (BDD) tend to show abnormalities in visual processing and frontostriatal systems (Feusner et al., 2010), with a tendency to be overly attentive to details rather than processing large or global features (Madsen et al., 2013). Given that, one might speculate that Rorschach variables deemed to indicate distorted perception (such as Form Quality minus, or FQ-) or idiosyncratic or atypical focus of perception (such as responses with the often small, Unusual Detail blot locations, or Dd) should associate with discernible brain activity patterns analogous to those found in individuals with AN or BDD. Demonstrating the existence of such an association could provide empirical support to the validity of said Rorschach variables. As another example, an interesting pattern of brain activations in the middle temporal area (MT) and inferior convexity of the prefrontal cortex has been observed when schizophrenia patients were exposed to a series of motion processing, visual tasks (Chen, 2011). As such, if similar patterns were observed also when schizophrenia patients taking the Rorschach produce FQ- human movement responses (or M-), then the classic interpretation of the M- variable as a misunderstanding of human activity or distorted ideation about people would receive an important, neurophysiological validation. However, despite the large, Rorschach research literature, there are few Rorschach neuroimaging studies. They are reviewed in the next section.

1.1. Physiological and Neurobiological Studies of the Rorschach

A few years ago, a number of studies have attempted to investigate the psychophysiological or autonomic correlates of the Rorschach. For example, Perry and colleagues have conducted a series of Rorschach studies implementing approaches such as the eye tracking (Minassian et al., 2005), the examination of the pupillary dilatation (Minassian et al., 2004), the inspection of the prepulse inhibition of the startle response (Perry et al., 1999), and the recording of the skin conductance (Perry et al., 1998). More recently, Giromini et al. (2016) tested the predictive validity of stress and distress Rorschach variables using electrodermal activity as criterion variable. Other authors also conducted similar studies, investigating the functioning of the autonomic nervous system in association with the administration of the Rorschach (e.g., Ganz, and Stäcker, 1991; Kettunen et al., 1998). In general, the results of these studies contributed to support the validity and utility of the Rorschach as a valuable assessment tool.

More recently, a few neuroimaging studies of the Rorschach have been conducted, too. Kircher and colleagues used fMRI to investigate the neural correlates of syntax production in schizophrenia during exposure to a subset of Rorschach inkblots (Kircher et al., 2005; Kircher et al., 2003; Kircher et al., 2002; Kircher et al., 2000). Asari and colleagues conducted voxel-based morphometry and functional connectivity analyses to investigate the hypothesis that the amygdala be involved in the production of unusual (i.e., poor form quality, or FQ-) responses (Asari et al., 2010a, 2010b). Some of us recently used EEG to show that attributing human movement (M) to the Rorschach inkblots likely associates with mirroring activity in the brain (Giromini et al., 2010; Pineda et al., 2011; Porcelli et al., 2013). Luciani et al. (2014) used EEG too: They investigated whether attribution of meaning to gray Rorschach inkblots vs. gray polygonal shapes would yield different patterns of EEG activations, and concluded that 'projection' during gray Rorschach cards might involve fronto-parietal circuits. Lastly, a near-infrared spectroscopy study (Hiraishi et al., 2012) recently inspected brain activity induced by various picture-based personality tests, and showed that exposure to a subset of Rorschach and Thematic Apperception Test (TAT; Murray, 1943) stimuli associated with a tendency toward right-hemisphere dominant activations.

1.2. The Current Study

Despite the large amount of Rorschach research conducted during the past decades, to date few studies have used neuroimaging techniques to investigate the Rorschach. In fact, no studies have yet described, via fMRI, the functional brain processes associated with the elaboration of Rorschach responses while exposed to the ten-inkblot stimuli. Currently, we do not really know what happens in the brain of a person who is looking at the Rorschach inkblots while thinking of what they might be.

The goal of the current study is to begin to fill this gap in the literature using fMRI to illuminate what brain areas are involved when one takes the Rorschach. With this first study, we intended to make a first step toward understanding the neuroanatomical processes involved in producing a Rorschach response. We anticipate that future research could draw on our findings to develop additional and more refined, hypothesis-driven, fMRI studies of the Rorschach.

2. Method

This study is part of a larger research project implemented to investigating the neural correlates of various Rorschach responses. For the purposes of the current paper, however, we did not look at any specific responses, but rather compared brain activity during exposure to the ten Rorschach inkblots vs. during fixation of a cross.

2.1. Participants

Twenty-six, nonclinical volunteers took part in this study. Ages ranged 17 to 28, with a mean age of 21.4 (SD = 2.3), and 13 were men. About 46% were Caucasian, about 38% Asian, and the remaining ones were Hispanic. The majority of the sample (about 85%) were undergraduate students recruited at University of California, San Diego (UCSD); the rest was comprised of adult volunteers recruited through word of mouth and flyers posted at Alliant International University – San Diego. None had history of psychiatric or neurological disease; all were right-handed and had normal or corrected-to-normal vision; all gave written consent prior to taking part in the study. UCSD students received class credits and $15 cash for participation; other participants earned $18. Prior to initiating the study, the applicable Institutional Review Board had approved the research project.

2.2. Procedures

Initially, outside the scanner, participants were informed that during the scanning sessions they would look at a series of inkblot designs, and that their task would be to look at each inkblot and think of what it might be. They were also informed that they should try to think of only one response at a time – i.e., that they should try to see only one thing per each inkblot design they would be exposed to – and that later, outside the scanner, they would be inquired about their responses.

Next, participants were entered into the scanner to begin the fMRI scanning sessions. First, a high-resolution whole-head T1-weighted anatomical scan was carried out. Next, during the functional session, participants were exposed to the entire set of Rorschach cards twice. Before each card, a fixation cross was presented on the screen: Each fixation cross lasted 16 seconds, and each Rorschach card lasted 10 seconds (for a schematic representation of the study design, see Figure 1).

---- Insert Fig. 1 about here ---

Lastly, outside the scanner, participants were shown all Rorschach cards one more time, and were inquired about their responses. All were able to remember most of what they thought of while into the scanner, with very few participants not being able to recall 100% of their responses.

2.3. Imaging and Data Analysis

A 3 T Siemens Trio Tim Scanner was used for this study. Anatomical scanning consisted of 160 T1-weighted slices covering the whole brain. Anatomic overlays of functional data and spatial normalization was obtained by means of a five-minute magnetization prepared, rapid-acquisition gradient echo image (MPRAGE). Field of view (FOV) was 240 × 240 × 160; voxel size was 1 mm^3.

Functional scanning consisted of 33 T2-weighted slice whole-brain, single-shot gradient echo (GE) echo-planar (EPI) sequence (TR/TE = 1969/25 ms, FA = 90°, FOV = 240 mm, matrix = 64 × 64, slice thickness/gap = 4/0 mm), which leads to a voxel resolution of 3.75 × 3.75 × 3.75 mm. Data analysis contrasted blood-oxygen level dependent (BOLD) associated with exposure to the Rorschach inkblots (100 time points, or 200 seconds) vs. fixation of a cross (160 time points, or 320 seconds). A false discovery rate (FDR) corrected alpha of .05 with minimum cluster size of k = 6 was adopted.

Imaging data were processed and visualized using Brain Voyager (Brain Innovation, Maastricht, the Netherlands). In line with standard procedures, preprocessing of functional data consisted of: (1) mean intensity adjustment of each slice based on the global intensity of the repeatedly measured images of the same slice; (2) 3D motion correction adjustment for small head movements, performed using trilinear interpolation algorithm; (3) spatial smoothing of the functional data, using a 3D Gaussian kernel with full width half maximum (FWHM) of 4 mm; (4) temporal filtering of frequencies below 3 cycles in time course (i.e., below .005 Hz), aimed at removing drifts due to scanner and/or physiological noise; (5) temporal smoothing of the functional data, using a Gaussian kernel with FWHM of 2.8 s.

Next, to facilitate precise anatomical identification of brain activity locations, as well as accurate inter-subject analysis, a series of additional steps were undertaken. First, for each subject, slice-based functional scans were co-registered with 3D high-resolution structural scan. Second, structural data were transformed into Talairach space (Talairach & Tournoux, 1998), the cerebrum being translated and rotated into the anterior-posterior commissure plane, and its borders being identified. Third, each subject's functional time course was transformed into a volume time course, by means of anatomical-functional co-registration matrix and Talairach reference points. Lastly, a multi-subject design matrix was specified, to obtain functional maps reflecting the neural activity of Rorschach vs. fixation conditions. To account for hemodynamic delay (Boynton et al., 1996), each defined box-car was convolved with a predefined hemodynamic response function (HRF). A general linear model (GLM) with separate subject predictors was then performed on the entire sample, so as to generate the actual functional activation maps (i.e., inkblots > fixation). To correct for multiple comparisons error, a false discovery rate (FDR) adjustment was adopted (Benjamini & Hochberg, 1995; Genovese et al., 2002), with $q = 0.05$. Finally, clusters of activations were determined by using ClassTAL, an online available script in Matlab (http://precedings.nature.com/documents/6142/version/1).

3. Results

Cortical activations associated with exposure to the Rorschach inkblots are reported in Figure 2. Table 1 presents the labels and the coordinates of the local maxima of the active blobs.

---- Insert Fig. 2 and Tab 1 about here ---

Consistent with the fact that the Rorschach is mainly a visual task, a large temporo-occipital activation, extending to the posterior part of the inferior temporal gyrus was observed. Interestingly, rather than in the primary visual cortex, the strongest activations in these posterior regions were found in the extrastriate cortex, which is devoted to more complex visual tasks (Orban, 2008). Additionally, both the dorsal and – to a lesser extent – the ventral attention systems (Corbetta and Shulman, 2002; Corbetta et al., 2008; Macaluso, 2010; Macaluso and Driver, 2005; Vossel et al., 2014) were engaged, as indicated by characteristic patterns of activations in both the dorsal and ventral fronto-parietal pathways. Thus, exposure to Rorschach stimuli triggered both top-down and bottom-up attentional processes.

Some sub-cortical areas also showed significant activations, as highlighted by Figure 3. Specifically, the caudate head, the anterior part of the thalamus, putamen and pallidus, a large portion of the pulvinar, and the mammillary bodies were significantly more active during exposure to the inkblot stimuli than during fixation of a cross. Because these areas are part of the limbic system and likely play a key role in the processing and perception of emotions, especially in relationship to memory (Béracochéa, 2005), this finding has important implications for the Rorschach research.

---- Insert Fig. 3 about here ---

Figure 4 presents the degree of lateralization in the brain areas triggered by exposure to the Rorschach. Remarkably, all the activations were bilateral. Only few areas showed a certain degree of lateralization (for a more analytical description see Tab 1): the lingual, superior occipital, middle temporal gyri and the substantia nigra were more right lateralized; the supramarginal, cingulate, inferior occipital, medial and superior frontal gyri, inferior parietal lobule, medial dorsal thalami and insulae were more left lateralized.

---- Insert Fig. 4 about here ---

4. Discussion

The current study sought to investigate which areas of the brain get involved when a person is looking at the Rorschach inkblots, while thinking of what they might be. Using fMRI, we compared BOLD signals associated with exposure to the Rorschach vs. fixation of a cross. Results from 26 healthy volunteers showed that compared to the fixation task, the Rorschach condition associated with higher temporo-occipital as well as fronto-parietal activations, and with greater activity in some small, sub-cortical regions included in the limbic system.

The fact that a large temporo-occipital activation was observed is not surprising. The Rorschach is mainly a visual task, and a person who observes an inkblot design trying to answer the question “what might this be?” presumably scans the stimulus and processes the visual information, prior to producing a response. As such, his/her brain temporo-occipital, visual areas are certainly engaged during these processes. Along the same lines, notable differences between the two experimental conditions (i.e., fixation of a cross vs. exposure to the Rorschach inkblots) were found also in the extrastriate cortex. This large region of the brain includes non-primary visual areas such as V2, V3, and MT/V5, and is often referred to as the associative visual cortex as it elaborates the inputs from the primary visual area, V1, by integrating multiple features such as the color, the shape, or the perception of motion (for a review, see Orban, 2008). Lesions in the extrastriate cortex, in fact, typically impair functions such as the discrimination between form and texture or the perception of motion (Mather, 2009). From the point of view of the Rorschach assessment, thus, one may speculate that this posterior region might be implicated in the processes that determine *why* and/or *how* the respondent sees what s/he sees, i.e., which characteristics of the inkblot (shape, color, etc.) made the respondent produce his/her response. Given that, it is possible that the extrastriate cortex contributes to originating the so-called “determinants” of the Rorschach responses (Exner, 2003; Meyer et al., 2011, Rorschach, 1921), which include scores for movement, texture or tactile impressions, depth, etc.

Two attentional networks were engaged during observation of the inkblot designs. The most activated one was the ‘dorsal attention system’ (Corbetta and Shulman, 2002), which is typically involved in top-down attentional processes, where the allocation of the attention is guided “voluntarily” toward specific locations or features (Vossel et al., 2014). This finding, in our view, reflects the fact that when a person tries to find his/her answer to the question “what might this be?” he or she likely screens some areas of the inkblot actively, searching for the best locations, within the card, to produce and deliver his/her response. Interestingly, however, the “ventral attention system” (Corbetta and Shulman, 2002; Corbetta et al., 2008; Macaluso, 2010; Macaluso and Driver, 2005) was engaged too, during this process. This ventral system is known to reflect bottom-up, stimulus-driven attentional processes, where the person becomes suddenly attracted to something in the environment that beforehand he or she was not paying much attention to. Accordingly, this finding suggests that during the Rorschach administration, not only the respondent directs his/her attention “voluntarily” towards specific locations of the stimulus, but certain features of the blots trigger some shifts of attention, too. This finding, thus, is in line with the Rorschach literature indicating that some features of the inkblot stimuli tend to ‘catch’ the attention of the respondent more than others, thus favoring certain vs. other responses (e.g., Exner, 2003; Meyer et al., 2011). One of the most famous examples of this phenomenon, also known as the “card pull” (Exner, 2003), probably occurs in Card III, where some nuances of the inkblot in a specific location often elicit the respondent to see a hill or boot, thus leading him/her to think of a human being and/or of a leg. The activation of these fronto-parietal attentional networks is also somewhat in line with Luciani et al. (2014), who suggested that attending to gray Rorschach cards might involve fronto-parietal circuits.

As shown in Figure 3, among other sub-cortical areas, the Rorschach task strongly activated the anterior section of the thalamus, a large portion of the pulvinar, and part of the mammillary bodies. These areas are part of the limbic system and are thought to contribute to the perception and processing of emotions, especially in relationship to memory (Béracochéa, 2005). The pulvinar, in particular, seems to play a key role in the non-conscious perception of emotional signals (Tamietto and de Gelder, 2010). Indeed, because it is monosynaptically connected with the amygdala (Romanski et al., 1997), it is supposed to serve as key rely for the rapid transmission of non-consciously processed, emotionally loaded, visual information (de Gelder and Hadjikhani, 2006; Morris et al., 2001; de Gelder et al., 2005). In line with this hypothesis, lesions of the pulvinar typically result in the abolishment of the automatic attention-grabbing effect of emotionally loaded stimuli (Ward et al., 2005). From the point of view of the Rorschach assessment, thus, this finding is particularly intriguing. Essentially, it reveals that looking at the Rorschach inkblots while thinking of what they might be activates areas of the brain that are implicated in the perception and processing of emotions and emotional memories. Thus, whether or not to focus on these emotionally loaded features or memories, and whether or not to report experiencing any of these emotional inputs, is probably up to the respondent. As such, our study indirectly provides support to the idea that the Rorschach may be used to investigate the respondent's ability and willingness to focus on, talk about, and/or deal with emotionally loaded stimuli, contents and/or memories. Indeed, several variables both in the Comprehensive System (CS; Exner, 2003) and in the recently developed, Rorschach Performance Assessment System (R-PAS; Meyer et al., 2011) attempt to address these sources of information.

Contrary to a recent, near-infrared spectroscopy study conducted by Hiraishi et al. (2012), our fMRI investigation did not show noteworthy right-hemisphere dominant activations. In fact, most of the brain areas activated by the Rorschach condition were not much lateralized (e.g., see cuneus and precuneus in Figure 4). Only the lingual, superior occipital, and middle temporal gyri and the substantia nigra showed some right lateralization, consistent with Hiraishi et al. (2012). Some other areas, conversely, showed left lateralization. Possibly, the discrepancy between Hiraishi et al.'s (2012) findings and ours might depend on technical (e.g., using near-infrared spectroscopy vs. fMRI; see Muthalib et al., 2013) and/or procedural (e.g., using a subset vs. the entire set of Rorschach cards) differences between the two studies. In any case, additional studies are sorely needed to better understand the extent to which being administered the Rorschach may or may not associate with lateralized activity in the brain.

Like all research studies, our study also is not without limitations. A first is that using a fixation cross as the baseline condition for the Rorschach task may be non-optimal. Indeed, the two conditions were highly different from each other in terms of both assigned task (i.e., fixating vs. thinking of what an inkblot might be) and visual stimulation (i.e., a cross vs. complex images). Perhaps future studies might try to use scrambled pictures or non-Rorschach inkblot designs, and/or try to test different tasks or instructions. On the other hand, using a fixation cross as baseline condition is a widely adopted procedure for fMRI studies, and it is consistent with previous EEG studies of the Rorschach conducted by some of us (i.e., Giromini et al., 2010; Pineda et al., 2011; Porcelli et al., 2013). Furthermore, any alternative solutions concerning the baseline to be used for the current study would have some pros but also some cons. Just as an example, if we used scrambled images rather than a cross, then we could not ascertain that the respondent were not trying to figure out what those scrambled images looked like to them, so that the comparison against the Rorschach task would be much more problematic.

A second limitation of this study is that the fMRI has a limited temporal resolution, so that it is relatively insensitive to temporal sequences of brain activity. Future study using both EEG and fMRI might overcome this limitation. Third, inspecting the brain activity of individuals being administered the Rorschach is not an easy task, and some technical constraints may have affected the results. For example, fMRI studies typically show the same stimuli several times, for only few seconds, so as to elicit the same mental process for a sustained period of time. However, such a design was not possible in our study, as the respondents need time to produce their responses, and since there are ten Rorschach cards, repeating each of them more than twice would result in an excessively long exposure to the magnetic field. Along the same lines, because the current study presented the Rorschach cards twice, both times in the standard administration order, we could not test whether the order of presentation of the cards could have had an impact on our results. Lastly, because fMRI designs have several technical constraints, our participants were not administered the Rorschach using standard procedures (e.g., we used the screen of a computer, we asked to think of one response at a time, etc.), which somewhat limits the ecological validity of our findings.

Despite these limitations, however, our investigation has contributed, for the first time, via fMRI, a map of the functional brain processes associated with the Rorschach response process. In line with the traditional, theoretical conceptualization of the psychological mechanisms underlying the production of Rorschach responses our results indicate that taking the Rorschach involves brain areas and networks important to (a) high-level visual processing, (b) top-down and bottom-up attentional processing, and (c) perception and processing of emotions and emotional memories. These processes are consistent with standard conceptions about the test including (1) scoring distinctions (e.g., between texture and movement determinants), (2) theoretical explanations of the visual, problem-solving components in the Rorschach response process, and (3) interpretive inferences regarding emotional and historical experiential (Rorschach, 1921, Exner, 2003; Meyer et al., 2011).

4.1 Future Directions

Because the current study did not use a hypothesis-driven approach, but rather broadly investigated what brain areas are involved when one takes the Rorschach, additional neuroimaging research is still needed to better understand the neuroanatomical underpinning of the complex psychological processes associated with generating Rorschach responses. Among others, an interesting question raised by our findings is whether the sub-cortical areas found to be engaged in our study would be more active when processing images dominated by color versus monochromic images. Indeed, because Rorschach responses involving chromatic color (e.g., "this is blood because it is red," "this is a colorful butterfly") likely reflect a spontaneous receptivity to the stimulating or compelling features of the environment, and are therefore interpreted as indexes of reactivity or emotionality (e.g., Exner, 2003; Meyer et al., 2011), it would be interesting to test whether the pulvinar and related brain regions identified by our study would be more active during exposure to colorful vs. monochromic inkblots. Likewise, given that the general level of cognitive sophistication or complexity of a Rorschach protocol largely affects its interpretation (Meyer et al., 2011), future research could also investigate the differences in brain activations between the simple identification of obvious Rorschach images (such as seeing two people on Card III) versus complex reasoning and more multifaceted and integrated responses. Our hope is that the current article will pave the way for future neuroimaging investigations designed to specifically address these left unanswered questions.

5. Conflicts of Interest

Donald Viglione owns a share in the corporate (LLC) that possesses rights to Rorschach Performance Assessment System; no other conflicts of interest are to be disclosed.

References

Asari, T., Konishi, S., Jimura, K., Chikazoe, J., Nakamura, N., Miyashita, Y., 2010a. Amygdalar enlargement associated with unique perception. Cortex 46, 94–99.

Asari, T., Konishi, S., Jimura, K., Chikazoe, J., Nakamura, N., Miyashita, Y., 2010b. Amygdalar modulation of frontotemporal connectivity during the inkblot test. Psychiat Res-Neuroim 182, 103–110.

Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Series B Stat Methodol 57(1), 289-300.

Béracochéa, D., 2005. Interaction between emotion and memory: Importance of mammillary bodies damage in a mouse model of the alcoholic Korsakoff syndrome. Neural Plast 15(4), 275-287.

Boynton, G. M., Engel, S. A., Glover, G. H., Heeger, D. J., 1996. Linear systems analysis of functional magnetic resonance imaging in human V1. J Neurosci 16(13), 4207-4221.

Chen, Y., 2011. Abnormal visual motion processing in schizophrenia: A review of research progress. Schizophr Bull 37(4), 709-715.

Corbetta, M, Shulman, G. L., 2002. Control of goal-directed and stimulus-driven attention in the brain. Nat Neurosci 3, 201–215.

Corbetta, M., Patel, G., Shulman, G. L., 2008. The reorienting system of the human brain: from environment to theory of mind. Neuron 58(3), 306–24.

de Gelder, B., Hadjikhani, N., 2006. Non-conscious recognition of emotional body language. Neuroreport 17, 583–586.

de Gelder, B., Morris, J. S., Dolan, R. J., 2005. Unconscious fear influences emotional awareness of faces and voices. P Natl Acad Sci USA 102, 18682–18687.

Exner, J.E., Jr., 2003. The Rorschach: A Comprehensive System, 4th ed. Wiley, New York.

Feusner, J.D., Moody, T., Hembacher, E., Townsend, J., McKinley, M., Hayley, M., Bookheimer, S., 2010. Abnormalities of visual processing and frontostriatal systems in body dysmorphic disorder. Arch Gen Psychiatry 67(2), 197-205.

Ganz, R.E., Stäcker, K. H., 1991. Zum Einflu–S von Persönlichkeitsmerkmalen auf die elektrodermale Orientierungsreaktion im Formdeuteversuch. [The influence of personality traits on the electrodermal orienting response in the Rorschach Inkblot Test.]. Zeitschrift für Differentielle und Diagnostische Psychologie 12(1), 27-32.

Genovese, C. R., Lazar, N. A., Nichols, T., 2002. Thresholding of statistical maps in functional neuroimaging using the false discovery rate. Neuroimage 15, 870-878.

Giromini, L., Ando', A., Morese, R., Salatino, A., Di Girolamo, M., Viglione, D.J., Zennaro, A., 2016. Rorschach Performance Assessment System (R-PAS) and vulnerability to stress: A preliminary study on electrodermal activity during stress. Psychiatry Res 246, 166-172.

Giromini, L., Porcelli, P., Viglione, D. J., Parolin, L., Pineda, J.A., 2011. The feeling of movement: EEG evidence for mirroring activity during the observations of static, ambiguous stimuli in the Rorschach cards. Biol Psychol 85, 233–241.

Greene, R. L., 2000. The MMPI–2: An interpretive manual, 2nd ed. Allyn & Bacon, Boston, MA.

Hiraishi, H., Haida, M., Matsumoto, M., Hayakawa, N., Inomata, S., Matsumoto, H., 2012. Differences of prefrontal cortex activity between picture-based personality tests: A near-infrared spectroscopy study. J Pers Assess 94, 366 –371.

Kettunen, J., Ravaja, N., Näätänen, P., Keskivaara, P., Keltikangas-Järvinen, L., 1998. The synchronization of electrodermal activity and heart rate and its relationship to energetic arousal: A time series approach. Biol Psychol 48, 209-225.

Kircher, T. T., Oh, T. M., Brammer, M. J., McGuire, P. K., 2005. Neural correlates of syntax production in schizophrenia. Brit J Psychiat 186, 209–14.

Kircher, T., Brammer, M., Williams, S., McGuire, P., 2000. Lexical retrieval during fluent speech production: An fMRI study. NeuroReport 11(18), 4093-4096.

Kircher, T., Liddle, P., Brammer, M., Murray, R., McGuire, P., 2003. Neuronale korrelate 'negativer' formaler denkstörungen [Neural correlates of negative formal thought disorder]. Der Nervenarzt 74(9), 748-754.

Kircher, T., Liddle, P., Brammer, M., Williams, S., Murray, R., McGuire, P., 2002. Reversed lateralization of temporal activation during speech production in thought disordered patients with schizophrenia. Psychol Med 32(3), 439-449.

Luciani, M., Cecchini, M., Altavilla, D., Palombo, L., Aceto, P., Ruggeri, G., Vecchio, F., Lai, C., 2014. Neural correlate of the projection of mental states on the not-structured visual stimuli. Neurosci Lett 573, 24-29.

Macaluso, E, Driver, J., 2005. Multisensory spatial interactions: a window onto functional integration in the human brain. Trends Neurosci 28(5), 264–71.

Macaluso, E., 2010. Orienting of spatial attention and the interplay between the senses. Cortex 46(3), 282–97.

Madsen, S.K., Bohon, C., Feusner, J.D. 2013. Visual processing in anorexia nervosa and body dysmorphic disorder: Similarities, differences, and future research directions. J Psychiatr Res 47(10), 1483-1491.

Mather, G., 2009. Foundations of sensation and perception, 2nd ed. Psychology Press, Hove, UK.

Meyer, G. J., Viglione, D. J., Mihura, J. L., Erard, R. E., Erdberg, P., 2011. Rorschach Performance Assessment System: Administration, coding, interpretation and technical manual. Rorschach Performance Assessment System, Toledo, OH.

Minassian, A., Granholm, E., Verney, S., Perry, W., 2004. Pupillary dilation to simple vs. complex tasks and its relationship to thought disturbance in schizophrenia patients. Int J Psychophysiol 52, 53–62.

Minassian, A., Granholm, E., Verney, S., Perry, W., 2005. Visual scanning deficits in schizophrenia and their relationship to executive functioning impairment. Schizoph Res 74, 69-79.

Morris, J. S., de Gelder, B., Weiskrantz, L., Dolan, R. J., 2001. Differential extrageniculostriate and amygdala responses to presentation of emotional faces in a cortically blind field. Brain 124, 1241–1252.

Murray, H. A., 1943. Thematic Apperception Test manual. Harvard University Press, Cambridge, MA.

Muthalib, M., Anwar, A. R., Perrey, S., Dat, M., Galka, A., Wolff, S., Heute, U., Deuschl, G., Raethjen, J., Muthuraman, M., 2013. Multimodal integration of fNIRS, fMRI and EEG neuroimaging. Clin Neurophysiol 124, 2060-2062.

Orban, G. A., 2008. Higher order visual processing in macaque extrastriate cortex. Physiol Rev 88, 59-89.

Perry, W., Felger, T, Braff, D., 1998. The relationship between skin conductance hyporesponsivity and perseverations in schizophrenia patients. Biol Psychiat 44, 459–465.

Perry, W., Geyer, M. A., Braff, D. L., 1999. Sensorimotor gating and thought disturbance measured in close temporal proximity in schizophrenic patients. Arch Gen Psychiat 56, 277–281.

Pineda, J. A., Giromini, L., Porcelli, P., Parolin, L., Viglione, D. J., 2011. Mu suppression and human movement responses to the Rorschach test. NeuroReport 22, 223–226.

Porcelli, P., Giromini, L., Parolin, L., Pineda, J. A., Viglione, D. J., 2013. Mirroring activity in the brain and movement determinant in the Rorschach test. J Pers Assess 95, 444-456.

Romanski, L. M., Giguere, M., Bates, J. F., Goldman-Rakic, P. S., 1997. Topographic organization of medial pulvinar connections with the prefrontal cortex in the rhesus monkey. J Comp Neurol 379, 313–332.

Rorschach, H., 1921. Psychodiagnostik [Psychodiagnostics]. Bern, Switzerland: Bircher.

Talairach, J., Tournoux, P., 1988. Co-planar stereotaxic atlas of the human brain. 3-Dimensional proportional system: An Approach to Cerebral Imaging. Thieme Medical Publishers, Inc., New York.

Tamietto, M., de Gelder, B., 2010. Neural bases of the non-conscious perception of emotional signals. Nat Neurosci 11, 697-709.

Vossel, S., Geng, J. J., Fink, G. R., 2013. Dorsal and ventral attention systems: Distinct neural circuits but collaborative roles. Neuroscientist 20(2), 150-159.

Ward, R., Danziger, S., Bamford, S., 2005. Response to visual threat following damage to the pulvinar. Curr Biol 15, 571–573.

Table 1. Clusters of Activations, Lateralization, and Brodmann Coordinates of the Local Maxima of Active Blobs (FDR, q < .05).

Area	Voxels	Lateralization (L/R%)	Left BA	Right BA
Bilat Middle Occipital Gyrus (MOG) [a]	26068	55/45%	19, 18, 37, 39	19, 18, 37, 39
Bilat Fusiform Gyrus (FG) [a]	13981	53/47%	37, 19, 20, 36	37, 19, 20, 36
Bilat Middle Frontal Gyrus (MFG) [a]	12854	47/53%	46, 6, 9, 10	46, 6, 9, 11
Bilat Precuneus (Pcun) [a]	11105	46/54%	7, 19, 31	7, 19, 31
Bilat Inferior Frontal Gyrus (IFG) [a]	9466	55/45%	9, 47, 46, 45	9, 47, 46, 45
Bilat Lingual Gyrus (LG) [a]	9442	41/59%	18, 17, 19	18, 17, 19
Bilat Cuneus (Cun) [a]	9055	47/53%	18, 17, 19, 30	18, 17, 19, 30
Bilat Culmen (Cul) [a]	8102	50/50%	37, 36, 20, 35	37, 36, 20, 35
Bilat Parahippocampal Gyrus	6976	45/55%	36, 37, 35, 19	36, 37, 35, 19
Bilat Precentral Gyrus	6581	51/49%	6, 9	6, 9
Bilat Declive	5471	53/47%	19, 37, 18,	19, 37, 18
Bilat Middle Temporal Gyrus	5401	42/58%	37, 39, 19, 20	37, 39, 19, 20
Bilat Superior Parietal Lobule	5360	51/49%	7	7
Bilat Inferior Occipital Gyrus	5002	59/41%	18, 19, 17	18, 19, 17
Bilat Inferior Parietal Lobule	4270	66/34%	40, 7, 5, 2	40, 7
Bilat Medial Frontal Gyrus	3325	67/33%	6, 32, 8	6, 32, 8, 24
Bilat Cingulate Gyrus	3237	62/38%	32, 24	32, 24
Bilat Superior Frontal Gyrus	3222	65/35%	6, 8, 10	6, 11, 8
Bilat Putamen	3033	57/43%	-	-
Bilat Caudate Body	2968	53/47%	-	-
Bilat Inferior Temporal Gyrus	2862	55/45%	37, 20, 19, 36	37, 20, 19
Bilat Insula	2431	59/41%	13, 47, 45	13, 47, 45
Bilat Red Nucleus	1222	54/46%	-	-
Bilat Medial Dorsal Nucleus	1217	63/37%	-	-

Bilat Pulvinar	1121	45/55%	-	-
Bilat Lateral Globus Pallidus	1066	55/45%	-	-
Bilat Caudate Head	963	49/51%	-	-
Bilat Anterior Nucleus	959	51/49%	-	-
Bilat Ventral Anterior Nucleus	795	54/46%	-	-
Bilat Substantia Nigra	632	35/65%	-	-
Bilat Postcentral Gyrus	629	50/50%	2, 40, 5	2, 40, 19,
Bilat Superior Occipital Gyrus	547	36/64%	19	19
Bilat Uncus	499	51/49%	20	20, 36
Bilat Medial Globus Pallidus	499	57/43%	-	-
Bilat Lateral Geniculum Body	425	49/51%	-	-
Bilat Ventral Lateral Nucleus	414	51/49%	-	-
Bilat Medial Geniculum Body	394	51/49%	-	-
Bilat Hippocampus	320	58/43%	-	-
Bilat Supramarginal Gyrus	149	96/4%	40	40
Bilat Out of Gyrus [b]	56816	50/50%	37, 19, 7, 6	37, 19, 7, 6

Notes. This table was generated by using ClassTAL, an online available Matlab script (http://precedings.nature.com/documents/6142/version/1). In case of big blobs of activations encompassing multiple clusters of anatomical regions, each cluster is presented separately. For each cluster, the following information is presented: 1) a summary label broadly describing the cluster; 2) the number of active voxels within the cluster; 3) the percentage of active voxels in the left vs. right hemisphere; 4) a more complete description of active Brodmann areas within the cluster. For example, within the cluster labeled "Bilat Precuneus," 11105 active voxels were found in Brodmann areas 7, 19, and 31; 46% of these voxels (i.e., 5108) were located in the left hemisphere, 54% (i.e., 5997) were located in the right hemisphere.

[a] For a graphical representation of this activation, see Figure 4.

[b] Out of gyrus = blobs that have a local maxima that falls out of the gray matter mask.

Figure 1. Layout of the Study Design.

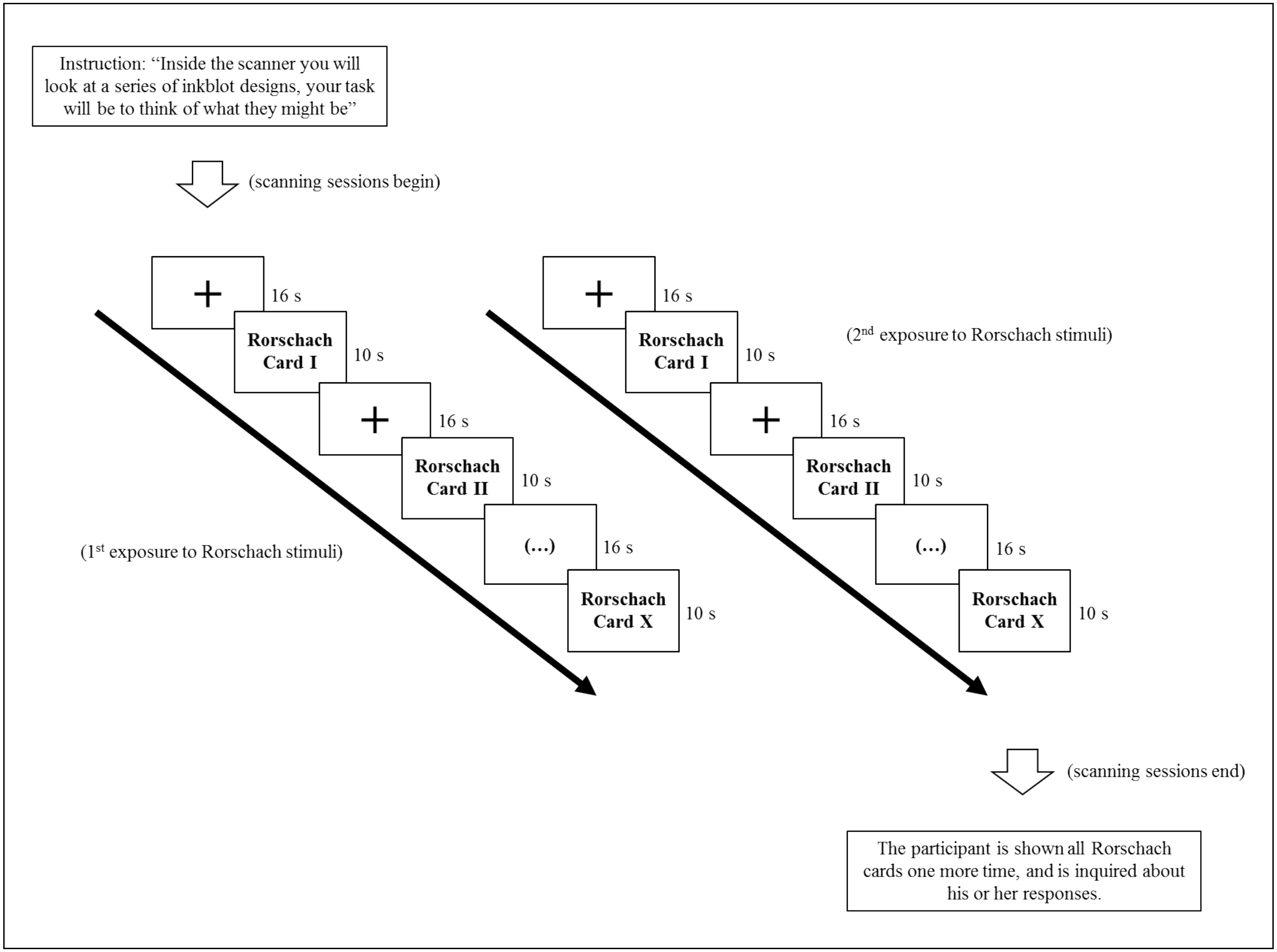


Figure 2. Cortical Activations Associated with Exposure to the Rorschach Inkblots.

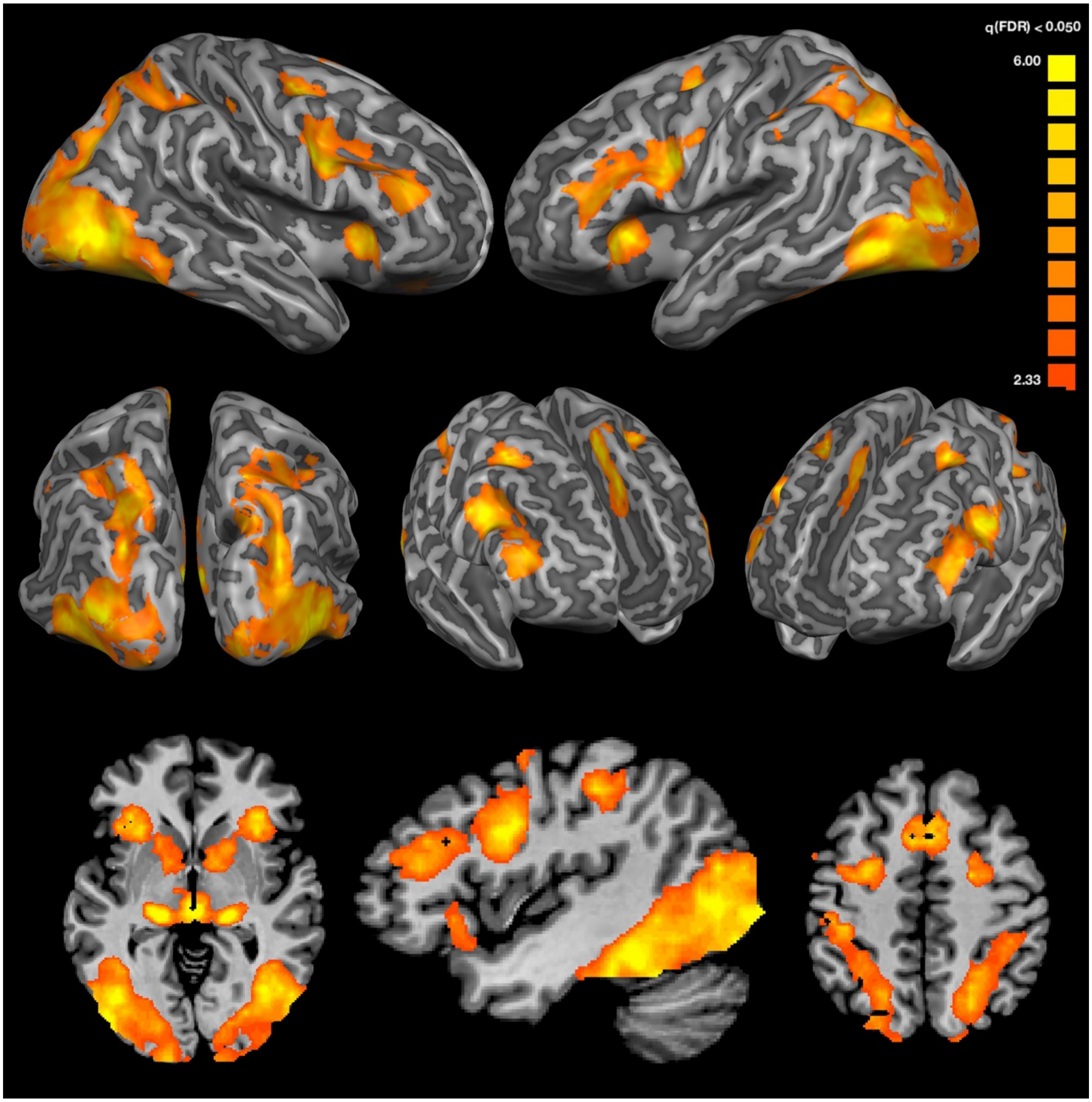
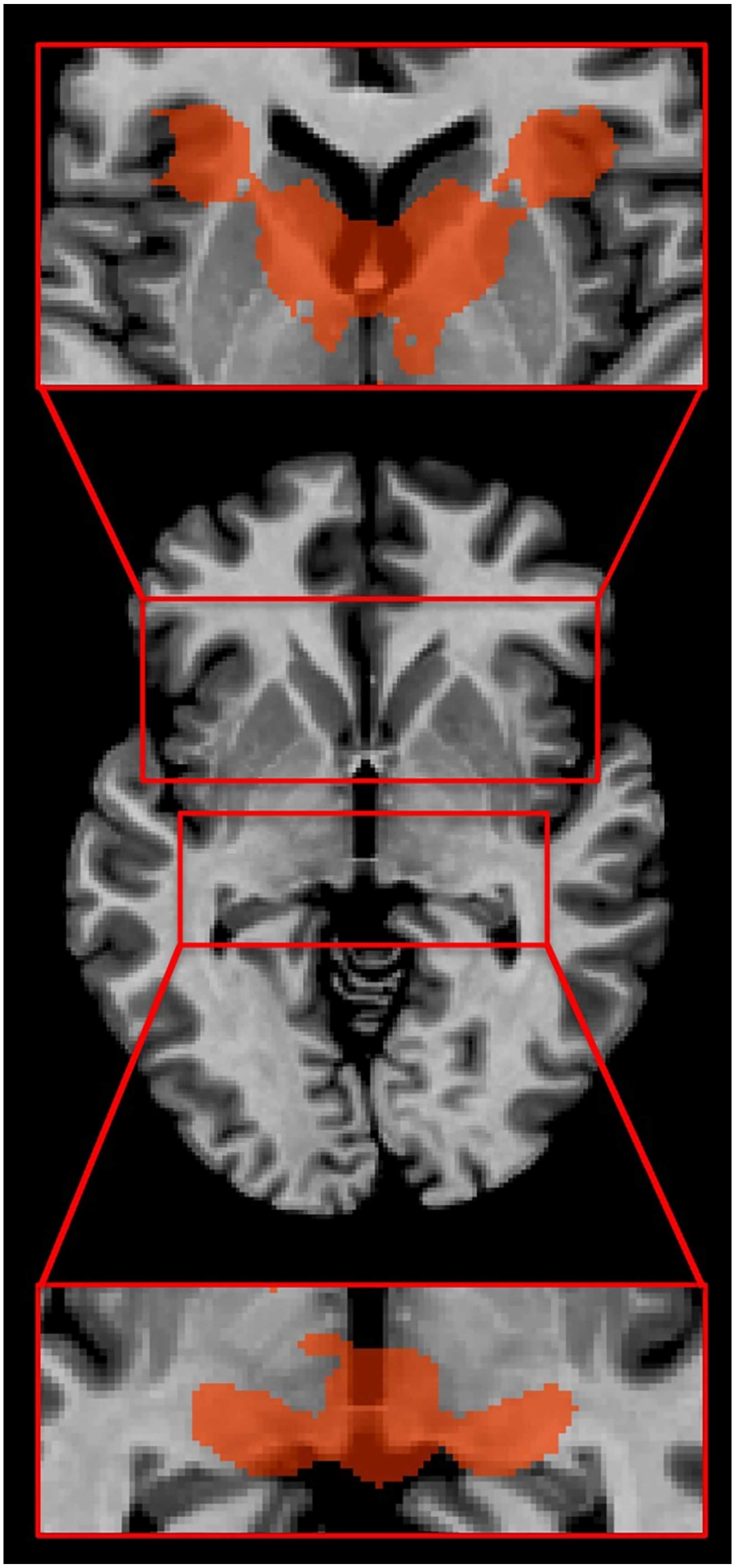
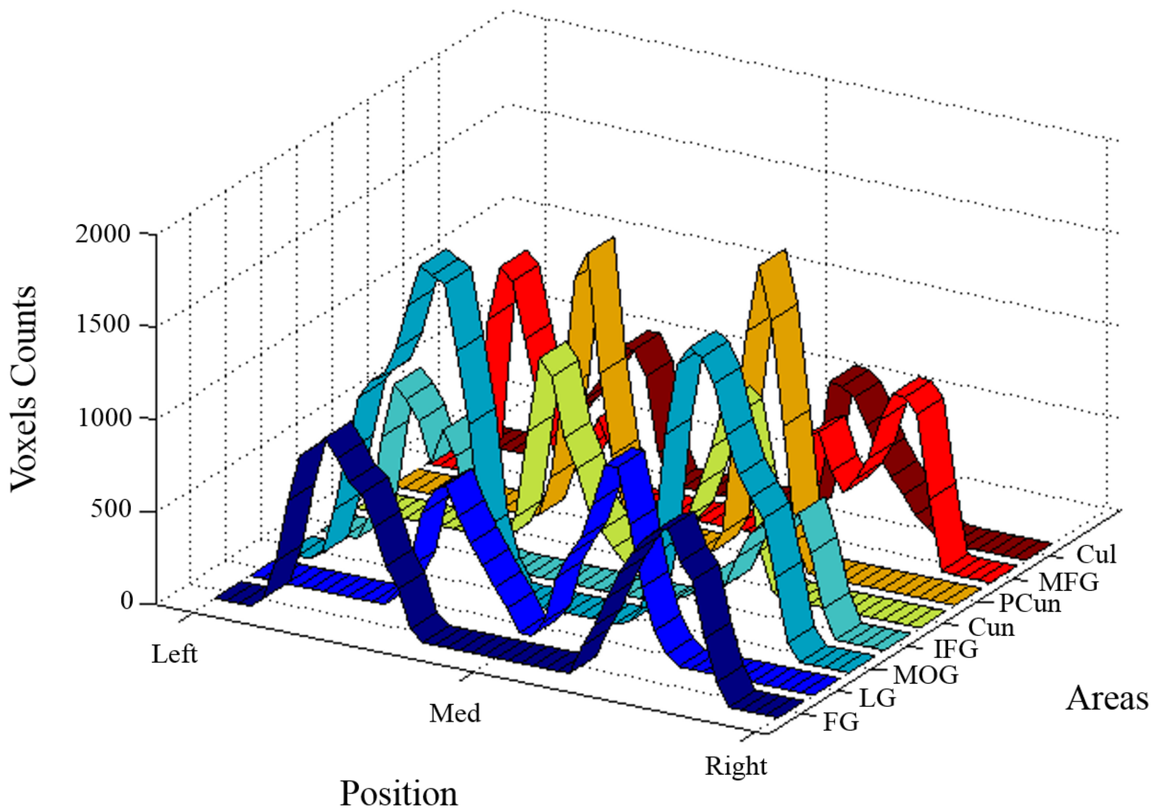


Figure 3. Sub-Cortical Activations Associated with Exposure to the Rorschach Inkblots.



Note. Statistically significant voxels at q (FDR) < .05 are highlighted in red.

Figure 4. Lateralization of Brain Activations Associated with Exposure to the Rorschach Cards.



Notes. This Figure was generated by using ClassTAL after upsampling all voxels at 1 × 1 × 1 mm (http://precedings.nature.com/documents/6142/version/1). Only the eight biggest active areas are shown in this figure; for a more detailed description see Table 1.

FG = Fusiform Gyrus; LG = Lingual Gyrus; MOG = Middle Occipital Gyrus; IFG = Inferior Frontal Gyrus; Cun = Cuneus; Pcun = Precuneus; MFG = Middle Frontal Gyrus; Cul = Culmen.

HIGHLIGHTS

- We used fMRI to inspect what brain areas get involved when one takes the Rorschach
- Participants (n = 26) were instructed to look at each inkblot and think of what it might be
- We compared BOLD signals associated with exposure to the Rorschach vs. fixation of a cross
- A GLM with separate subject predictors and FDR adjustment (q = 0.05) was performed on the entire sample
- The Rorschach condition activated brain areas typical of visual processing, top-down and bottom-up attentional networks, and perception and processing of emotions

Running Head: Rorschach and fMRI

Neural Activity during Production of Rorschach Responses: An fMRI Study

Luciano Giromini [a], Donald J. Viglione, Jr. [b], Alessandro Zennaro [a], & Franco Cauda [c]

[a] Department of Psychology, University of Turin, Italy;

[b] California School of Professional Psychology, Alliant International University, San Diego, CA, USA;

[c] GCS-fMRI University of Turin and Koelliker Hospital Turin, Italy.

Corresponding author:

Luciano Giromini, Ph.D., Department of Psychology, University of Turin, Italy.

Tel. (+39) 011 670 3060; email: luciano.giromini@unito.it

Email address of all other authors:

Donald J. Viglione Jr: dviglione@alliant.edu

Alessandro Zennaro: alessandro.zennaro@unito.it

Franco Cauda: franco.cauda@unito.it