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European Psychiatry

journal homepage: <http://www.europsy-journal.com>

Original article

# The Rubber Hand Illusion paradigm as a sensory learning process in patients with schizophrenia

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## ARTICLE INFO

## Article history:

Received 9 April 2015

Received in revised form 27 June 2015

Accepted 28 June 2015

Available online 25 September 2015

## Keywords:

Rubber Hand Illusion

Schizophrenia

Learning

Inpatients

Healthy controls

## ABSTRACT

**Objective:** The Rubber Hand Illusion (RHI) has previously been used to depict the hierarchy between visual, tactile and perceptual stimuli. Studies on schizophrenia inpatients (SZs) have found mixed results in the ability to first learn the illusion, and have yet to explain the learning process involved. This study's aim was two-fold: to examine the learning process of the RHI in SZs and healthy controls over time, and to better understand the relationship between psychotic symptoms and the RHI.

**Method:** Thirty schizophrenia inpatients and 30 healthy controls underwent five different trials of the RHI over a two-week period.

**Results:** As has been found in previous studies, SZs felt the initial illusion faster than healthy controls did, but their learning process throughout the trials was inconsistent. Furthermore, for SZs, no correlations between psychotic symptoms and the learning of the illusion emerged.

**Conclusion:** Healthy individuals show a delayed reaction to first feeling the illusion (due to latent inhibition), but easily learn the illusion over time. For SZs, both strength of the illusion and the ability to learn the illusion over time are inconsistent. The cognitive impairment in SZ impedes the learning process of the RHI, and SZs are unable to utilize the repetition of the process as healthy individuals can.

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## 1. Introduction

The Rubber Hand Illusion (RHI) was first conducted to assess the effects of a three-way interaction between visual, tactile and perceptual concepts concerning the basis of bodily self-identification (i.e. the knowledge of where your body begins and ends). The RHI involves a constraint-satisfaction process operating between vision, touch and perception [2]. This experiment demonstrates the hierarchy between these three senses and proves the superiority of visual stimuli over other modalities. Further studies concerning the RHI were interested in body image and body ownership, i.e. the extent people feel their body belongs to them and have control over it [1,5,28], and reported that this illusion is so strong that threatening the rubber hand while conducting the illusion may actually elicit an anxious reaction in participants [8].

The RHI has been used in SZs in an attempt to better understand their perceived disturbances in self-processing and their sense of ownership [26]. Using the RHI, Peled et al. [23] found that SZs experienced the RHI more strongly and more quickly than healthy

controls did, thus showing that SZs had significant alterations in long latency evoked responses during the illusion, and that the strength of the illusion correlated with positive, but not negative symptoms [22]. In a more recent study, Germine et al. [12] tried to assess psychosis-like characteristics and their relationship to the RHI in healthy adults. Their study confirmed previous studies concerning hierarchy of visual perception, and magnified the finding that the development of psychosis might be related to distortion of body representation. These studies illustrated that SZs can perceive the rubber hand as their own without disowning their real hand, and coincide with schizophrenic delusions in which thought and body can be felt as being one's own and simultaneously belonging to someone else [22,26].

In a unique study conducted by Kaplan et al. [16], healthy controls were compared both to those suffering body dysmorphic disorder (BDD) and to SZs using the RHI. The authors hypothesized that people with BDD and SZ would experience the RHI more strongly than healthy controls, but did not find significant overall differences between them. This, however, may be due to a small sample size.

The RHI has been conducted in different settings (i.e. leaving the rubber hand parallel to the real hand, changing the degree of the hand) and has yielded different results (i.e. SZs feeling the results

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more strongly than healthy individuals or finding no difference between the groups). In all these studies, the RHI experiment has been conducted in a single trial, making it difficult to understand the learning process that actually takes place. Honma et al. [15] were the first to report multiple trials of the RHI. They assessed healthy adults for 3 consecutive days, following baseline assessment. In their study they found that the RHI could be improved by training, and that processes that affect learning (such as sleep) can affect the leaning process of the RHI.

Many studies have revealed the extent of learning and memory impairments in schizophrenia [21,24]. However, research has shown that some cognitive processes are impaired whereas others are not. One explanation might be that for schizophrenia there may be differences in explicit memory, such as recall and recognition, from conscious memory, but not from implicit memory for which consciousness is less required [13]. We feel that it may actually be sensory memory that is deficient in this disorder. In order to test this hypothesis, we conducted an experiment in which the RHI was used as a tool aimed at examining the learning response over time.

This study has two novel approaches to the known methodology concerning the RHI. First, to date, the RHI has almost always been performed using a one trial paradigm. In this study, we repeated the RHI for five different trials (on three different dates) over a two-week period. In accord with previous studies, we hypothesized that for healthy controls, the initial time it would take to feel the illusion (start time 1) would be longer than for SZs, but that for all participants the illusion strength would not change throughout repetition. Healthy controls would get better at learning the illusion over time (their start times would decrease from trial to trial). As this experiment has not been conducted on multiple trials for SZs, we had no directional hypotheses for this group. Second, using this approach we could follow both the start time and illusion strength over time, and also explore the relationship between psychotic symptoms and the RHI. Following previous research, we hypothesized that the stronger the psychotic symptoms, the stronger the illusion strength would be.

## 2. Methods

### 2.1. Participants

A total of 60 right-handed adults participated in this study; 30 were schizophrenia inpatients, diagnosed by a senior psychiatrist using the Clinical Interview for DSM-IV. All were hospitalized at Sha'ar Menashe Mental Health Center. The healthy controls were either undergraduate students at Ruppin Academic Center (who participated in the study as a research course requirement) or had previous acquaintance with the authors, having volunteered their participation. All the participants signed consent forms after being given a full explanation of the study. All students but one participated in all parts of the study.

Inclusion criteria consisted of a 3-month history of drug abuse free, and all healthy controls had no known psychiatric history. Exclusion criteria consisted of a history of neurologic disorders or drug abuse or the inability to sign an informed consent.

For schizophrenia, current hospitalization lasted between 11 days and 10.3 years, with a mean of 1.31 years ( $SD = 2.44$  years). There had between 0 and 47 previous hospitalizations (mean = 10.43,  $SD = 10.45$ ), and they had been diagnosed between almost one year and 30 years (mean = 13.02,  $SD = 8.61$ ).

There was a significant difference between the different groups in age. SZs were significantly older (mean = 37.37 years,  $SD = 11.16$ ) than healthy controls were (mean = 30.90,  $SD = 12.62$ ;  $t_{(58)} = -2.10$ ;  $P = .05$ ). There was also a significant difference between the groups in education. Healthy controls had

more education years (mean = 13.10 years,  $SD = 2.11$ ) than SZs did (mean = 11.27,  $SD = 1.60$ ;  $t_{(57)} = 3.78$ ;  $P = .000$ ). There was a significant difference between groups concerning sex of the participants. In the schizophrenia group, there were 24 (80%) males, compared to 15 (50%) in the control group ( $\chi^2_{(1)} = 5.93$ ,  $P = .02$ ).

There were no significant differences between groups in religion. Of the SZ, 23 (76.7%) were Jewish, 5 (16.7%) were Muslim, 1 (3.3%) was Christian, and 1 (3.3%) did not report his religion. Of the controls, 28 (93.3%) were Jewish, and the remaining 2 (6.7%) did not report their religion. No control participants were taking medication, and participants in both groups denied recreational drug use during an initial screening interview and a diagnostic interview.

### 2.2. Consent

The Helsinki committee residing in the hospital assessed all ethical issues and gave its consent to the study. An independent psychiatrist assessed the SZ's ability to give written and oral consent. Before beginning the experiment, all participants gave written consent and were asked to participate in all three parts of the study over a two-week period. On each of the remaining trials, they were asked again to give oral consent to participate, and were informed that they had a right to discontinue their participation in the study at any moment.

### 2.3. Measures

After completing the RHI on the first day, all participants filled out online questionnaires that included questions regarding demographic data, illusion strength, and body perception. A research assistant assisted the SZs to complete the online questionnaires, if they had questions. There were no dropouts in either group. One SZ was discharged before he could complete one of the online questionnaires. One of the healthy controls completed his class requirements early, and thus did not complete one of the online questionnaires. Both participants were included in the study, nonetheless.

#### 2.3.1. Start time

Start time was reported as the first time the change was described as "feeling the rubber hand as my own" [2,23]. In order to refrain from any confounding of suggestibility, we used a very amorphous phrase: "Please tell me if you feel any change in your hand". When participants said they felt something that did not exactly reflect feeling the rubber hand as their own, we continued with the trial. Start time was reported in each trial (the illusion was performed once on the first day, twice on the second day, and twice on the third day). The participant was then instructed to report if and when the illusion ceased. If the illusion did not stop, brushing was ceased after the subject felt the illusion for three continuous minutes.

#### 2.3.2. Illusion strength

The definition of illusion strength was adapted from former experiments [2,23]. After concluding the experiment on each of the trial days, participants were asked to rate the perceptual effect of the RHI by answering the question "I feel as if the rubber hand was my hand" on a 1–7 Likert type scale rating 1 as "not at all" and 7 as "very much".

#### 2.3.3. Learning strength

Learning strength was described as the subtraction between the number of minutes it took for the participant to feel the illusion on the first trial and the time it took to feel the illusion on the fifth trial (the third day).

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