Chapter 15

Reality monitoring and mental imagery vividness

Summary

It is generally acknowledged that hallucinations in schizophrenia are a result of the erroneous attribution of internally generated information to an external source. Distortions in mental imagery vividness may underlie such confusions. We investigated performance of 43 patients with schizophrenia on multiple behavioral measures of auditory and visual mental imagery and perception, a measure of reality monitoring and a signal detection measure. Hallucinating patients were contrasted with non-hallucinating patients, after controlling for attentional factors that may influence task performance. We replicated earlier findings of significantly more source discrimination errors in hallucinating patients compared to non-hallucinating patients. No differences emerged on any of the mental imagery measures, nor on criterion bias in signal detection. Our results provide strong evidence that there is no trait-related distortion of mental imagery in patients with hallucinations.

Introduction
An increasing number of recent studies report that hallucination-prone patients with schizophrenia have difficulties in discriminating between an internally generated, imagined event and an externally presented, real event (Bentall & Slade, 1985; Bentall et al., 1991; Morrison & Haddock, 1997; Brébion et al., 1998; Johns & McGuire, 1999; Böcker et al. 2000; Brébion et al., 2000; Franck et al. 2000). Such difficulties may arise from one of three possible mechanisms, or a combination of these (Böcker et al. 2000). The first possibility concerns deficits in perception: degraded percepts will more easily be confounded with mental images. Second, an increase in the “vividness” of mental images, in which images have more sensory characteristics than expected by the cognitive system, may lead to confusions between percepts and images. Finally, a bias in a meta-cognitive process involved in monitoring the source of information that is processed in our brains could account for the confusion. Specifically, it has been hypothesized that reality monitoring biases, distinguishing between internally generated information and externally presented information, may underlie hallucinations in schizophrenia (Slade & Bentall, 1988).

Clearly, the recent research reporting biases in discriminating between imagined events and an externally presented events, is consistent with the third, “reality monitoring” hypothesis. This is not to say, however, that alterations in imagery or perception could not underlie such confusions. Research examining these hypotheses may more precisely delineate the cognitive mechanisms involved in hallucination. Regarding the perception hypothesis, Böcker et al. (2000) compared hallucinating versus non-hallucinating patients on measures of basic auditory and visual perception, specifically sensory acuity. No significant differences were observed. However, a recent study by McKay et al. (2000) also failed to find deficits in basic (low-level) perception associated with hallucinations, but did find higher order impairments. The authors administered a wide range of auditory perception tests to hallucinating and nonhallucinating schizophrenic patients and to normal comparison subjects. Although all patients

1 A distinction has been made between the terms “reality monitoring” and “reality discrimination”, where the latter refers to distinguishing “on-line” between real and imaginal events, whereas reality monitoring refers to memories of the (internal versus external) source of earlier presented information (Bentall, 1990). However, following recent authors (e.g. Brébion et al., 2000) we will use the terms interchangeably, as they concern the same psychological construct.
with schizophrenia appeared to perform worse on higher order perceptual tasks, this dysfunction was more pronounced for the hallucinating patients.

Most previous studies that investigated the imagery hypothesis of hallucinations (e.g., Roman & Landis, 1945; Mintz and Alpert, 1972; Starker & Jolin, 1982) did not include adequate behavioral measures of mental imagery, which may explain the inconsistent results. Two recent studies assessed the relation between mental imagery and hallucination with objective, behavioral measures (Evans et al., 2000; Böcker et al. 2000). Evans et al. (2000) only used auditory measures and failed to find differences between hallucinating and non-hallucinating patients. Böcker et al. (2000) assessed imagery and perception in the auditory and visual modalities. Consistent with Evans et al. (2000), no between-group differences were observed. However, after performing within-group comparisons, they observed more vivid auditory than visual imagery in hallucinating patients (that hallucinated in the auditory modality). This difference was not observed in the non-hallucinating group. Moreover, in a recent cognitive neuropsychiatric case-study (Aleman et al., submitted), we observed a modality-specific imbalance between imagery and perception in a patient with continuous auditory hallucinations, compared to five non-hallucinating patients. Specifically, whereas control subjects always perform better on a perception than on an imagery condition of the same task (the perception-superiority effect), this patient showed the reverse (imagery>perception) in the auditory, but not visual modality.

Our aim was twofold. First, to replicate the finding of reality monitoring errors in relation to hallucinations, and, second, to investigate whether differences in imagery vividness underlie such errors. Thus, the present study was designed as a thorough follow-up to the study by Böcker et al. (2000). Measures of imagery and perception were included, as well as measures of discrimination bias and reality monitoring. Specifically, the design was improved on five points with respect to earlier studies. First, a more comprehensive evaluation of imagery and perception was carried out by including more (behavioral) measures. Second, larger patient groups were studied. Third, patients with more severe hallucinations were included. Fourth, a subgroup of patients was included that had never hallucinated at all. Finally, we controlled statistically for non-specific attentional factors that contribute to cognitive test performance.
Method

Subjects
Forty-three patients with a clinical diagnosis of schizophrenia participated in the present study. They were recruited from the Schizophrenia Research Unit of the Department of Psychiatry, University Medical Center, and from a local Psychiatric Hospital (Willem Amtz Huis, H.C. Rümke Groep). DSM-IV diagnosis was established on the basis of the life-time version of the Comprehensive Assessment of Symptoms and History (CASH; Andreasen, 1987). With the exception of two patients, all were on neuroleptic treatment (Table 1). Clinical ratings were made from the Positive And Negative Symptom Scale (PANSS; Kay, Opler and Fiszbein, 1986), regarding the individual symptoms during the week preceding the interview. The interview, by the first author, who reached consensus with a second rater, took place on the first day of testing. Twenty patients had experienced hallucinations, ranging from a mild degree (once or twice, without behavioral consequences, score 3) to a very severe degree (hallucinations dominate thinking and behavior, causing verbal and behavioral reactions, score 7). Patients were included in the non-hallucinating group (N = 23) if they were hallucination-free for at least three months prior to testing (as indicated by self-report and confirmed by the consulting clinician). Eleven patients had never experienced hallucinations. Table 1 lists demographic and clinical characteristics of the patients included in the study.

Testing Materials
Reality monitoring, discrimination bias, and imagery/perception relations were tested by use of experimental psychological methods. To control for non-specific attentional factors, measures were included of attention and working memory, in the auditory and visual modality. These were the digit span forward and backward, from the Wechsler Adult Intelligence Scale (Wechsler, 1955), and the Visual Elevator test from the Everyday Attention Test (EAT; Robertson et al. 1996), respectively.

Reality monitoring and discrimination bias
Reality monitoring. This was an adaptation of the reality monitoring task described by Harvey (1985). During the learning-phase, one of the three most typical words (e.g., 'Gold') in one of twenty categories from Van Loon-Vervoorn and Pijpers-Kooiman (1988), was read aloud to the subjects. For a second word
the category-name plus the first letter were presented (e.g. 'Metal-I....') with the assignment to image the first word which came to mind, as if actually spoken.

Table 1. Demographic and clinical characteristics of the studied sample

<table>
<thead>
<tr>
<th></th>
<th>Patients with hallucinations (N=20)</th>
<th>Patients without hallucinations (N=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education¹</td>
<td>12.9 (3.5)</td>
<td>13.5 (2.8)</td>
</tr>
<tr>
<td>Age¹</td>
<td>32.2 (8.7)</td>
<td>29.5 (6.4)</td>
</tr>
<tr>
<td>Duration of illness¹</td>
<td>10.1 (8.7)</td>
<td>4.4 (4.4)*</td>
</tr>
<tr>
<td>Number of hospitalisations</td>
<td>3.1 (2.1)</td>
<td>2.1 (1.3)</td>
</tr>
<tr>
<td>Hallucination rating (PANSS)</td>
<td>4.5 (1.1)</td>
<td>1 (0.0)**</td>
</tr>
<tr>
<td>Positive symptoms (PANSS)²</td>
<td>11.8 (4.3)</td>
<td>11.0 (4.5)</td>
</tr>
<tr>
<td>Negative symptoms (PANSS)</td>
<td>15.1 (6.1)</td>
<td>17.7 (6.5)</td>
</tr>
<tr>
<td>General psychopathology (PANSS)</td>
<td>31.0 (9.3)</td>
<td>31.5 (8.0)</td>
</tr>
</tbody>
</table>

¹in years, ²after subtraction of hallucination ratings
*p<0.05; ***p<0.001

In the test-phase the participants had to indicate verbally for each of 30 words whether it was perceived earlier ('Gold'), imaged earlier ('Iron') or whether it concerned a new word ('Copper'). This was done immediately after presentation of the words (immediate recognition) and again after 15 minutes (delayed recognition). Between both tests, another task was performed (the letter imagery task). Reality monitoring data were analyzed by calculating a source discrimination parameter, and two sensitivity parameters. The source discrimination parameter was the average conditional source identification measure (ACSIM), which, in contrast to more traditional measures, is independent of item recognition (Murnane & Bayen, 1996). In addition, we calculated recognition parameters $D_1$ and $D_2$ (Batchelder & Riefer, 1990), which refer to sensitivity for words that were heared (externally presented) and words that were imaged (internally generated), respectively.
Discrimination bias. The non-parametric measure for response bias (B) is regarded as an indicator of external attribution bias, an important factor in reality discrimination. A stronger external attribution bias leads to more false positives, i.e., more internal events being classified as external. It is determined in a signal-detection task.

The subjects were presented with 100 trials on which they were requested to indicate whether they perceived a particular word presented at 60 to 65 dB(A) in 72 dB(A) white background noise. They verbally indicated this on a 5-point rating scale with the anchors being ‘definitely yes’, ‘probably yes’, ‘don’t know’, ‘probably not’ or ‘definitely not’. On 50% of the trials the word which was asked for had indeed been presented. Bentall and Slade (1985) found the response bias, which is inversely related to the external attribution bias, to be weaker in hallucinating subjects, who were more prone to acknowledge that they heard a stimulus in the noise.

The number of false alarms on the imagery-perception interaction tasks was also considered a measure of discrimination bias.

Relation mental imagery-perception

First, four tests will be described that concern concerned a comparison between imagery and perception. Subsequently, two measures will be described that are aimed at the interaction between imagery and perception (cf. Aleman et al. 2000; Böcker et al. 2000).

Imagery-perception comparison. The first two tasks (which we will call the visual and auditory trial comparison task) concerned a quantitative comparison between imagery and perception of visual form characteristics of common objects (this task was adapted from Mehta et al. 1992) or sound characteristics of common sounds (auditory version; Aleman et al., 2000). Visual modality. The task consists of 22 object names printed on cards and 22 triads of line drawings of common objects (Snodgrass and Vanderward, 1980). From the triads of line drawings, the item that is most deviant in terms of visual form characteristics has to be indicated. In the perceptual condition the line drawings are actually presented, whereas in the imagery condition the object names are read from cards. For example, in the perceptual condition pictures of the following three objects are presented: “pumpkin”, “lettuce” and “tomato”, whereas in the imagery condition only the names of these three objects were presented to the subject (figure 1). Thus, the imagery condition requires the participants to form mental images in order to be able to make a correct
judgement (which in the example given would be “lettuce”). A difference-score was calculated by subtracting the percentage correct responses in the imagery condition from the percentage correct responses in the perceptual condition. **Auditory modality.** The auditory task was similar to the visual version in that a triad of common sounds was presented, and participants had to indicate the item that is most deviant in terms of acoustic characteristics. In the perceptual condition the sounds were actually presented (by the computer), whereas in the imagery condition the names of the sounds were read from cards. An example of a sound triad that was presented is “crying baby”, “laughing baby” and “meowing cat”, where “laughing baby” was regarded the deviant item.

The third task concerned **Letter imagery.** We adapted the letter imagery task used by Kosslyn et al. (1988). The subject is asked whether an X-mark, presented in a 4x5 grid, falls on a capital letter. In the imagery condition, the letter is not actually presented in the grid, but must be imaged by the subject. For example, after a fixation point a lowercase letter ‘f’ is presented, followed by an empty grid with the X-mark at the lower right corner. The subject must decide whether the target would fall on an uppercase letter ‘F’ or not. In the perception condition, the letter actually appeared in the grid (figure 2). Eight letters were randomly presented during the task: ‘c’, ‘f’, ‘h’, ‘j’, ‘l’, ‘p’, ‘s’, ‘u’. Each condition of the task consisted of 32 trials, 4 trials for each of the letters (two “on” and two “off” trials for each letter). We modified the task slightly, in that we allowed the X-mark to appear only in cells in which the chance that the X-mark would cover a letter was equal (thus, no X-marks appeared in the most left column, as most capital letters would cover these cells). The difference in percentage correct responses between the imagery and perception condition was the dependent measure.

The last imagery-perception comparison task was of **Musical imagery.** This task of requires participants to mentally compare pitches of notes corresponding to song lyrics, and was adapted from Halpern (1988; experiment 2). Participants viewed the lyrics from the first line of a familiar Dutch song on a screen and were asked to decide whether, of two indicated lyrics (which were marked on both sides with asterisks and appeared in uppercase letters), the pitch of the second lyric was higher or lower than that corresponding to the first lyric. Lyric refers here to a monosyllabic word, or one syllable of a two-syllabic word. An English language example would be: “*OH* say can *YOU* see”, taken from the American national anthem. Participants responded by means of a key press. In the perceptual condition, participants were actually presented with the song,
which was played via a tape-recorder. The imagery condition was identical, with
the exception that the song was not presented, and participants had to rely on
their musical imagery in order to be able to perform the task correctly. Again, the
difference in percentage correct responses between the imagery and perception
condition was calculated.

**Imagery-perception interaction.** This test was based on the notion that
stimuli which are presented at the level of the absolute perception threshold are
detected more often when at the same time a person also images that stimulus. In
the visual modality this has been reported for dots at locations covered by a
concurrent image of a letter (Farah, 1989) and in the auditory modality for a tone
while the subjects imaged a tone of the same frequency (Farah and Smith, 1983).
At the first stage of this test absolute thresholds (for the duration of the target
dot and the loudness of the two target tones in 74 dB(A) white noise,
respectively) were determined by the staircase method. During the second stage
two series of 32 trials were presented in each modality, while the subjects were
imaging one of the two letters (capital T or H in a 5 * 5 square) or tones (440 or
1000 Hz). On 50% of the trials a target stimulus (dot or tone) was presented
while the subjects were imaging. On each trial subjects indicated verbally whether
or not they perceived a target stimulus. The difference score calculated from the
number of stimuli detected when the image was similar (in location or pitch) to
the target stimulus (25% of the trials), minus those detected when it was not
(another 25% of the trials), is a measure for the interaction between imagery and
perception. This difference is presumed to be larger in subjects with a more vivid
imagery, which are the hallucinating patients according to our second hypothesis.

**Procedure**
The auditory and visual tests were administered in two sessions, on different
days, with a maximum delay of one week. The order of the tests within one part
was fixed, to minimize interference on the one hand and to create standard filled
intervals on the other hand. A break was inserted halfway.
Experimental design and statistical analysis

This study focuses on the contrast between hallucinating and non-hallucinating patients. Comparing these two groups reveals the cognitive disturbances that probably contribute to the hallucinations. For direct comparisons between different imagery comparison tests the percentage correct responses was computed, because the measurement scales of the different tasks are not comparable. ANCOVA’s were carried out on the data, with tests of attention/working memory as covariate. Two--tailed significance levels are reported, with exception of the reality monitoring task, for which the strong expectations of the direction of the effect (based on theory and empirical findings) allowed the use of one-tailed levels.

Results

Although the two groups did not differ significantly on digit span nor on Visual Elevator performance, these measures were included as covariate in the analyses, in order to control for the portion of variance in the cognitive measures that could be explained by attentional factors.

Reality monitoring and signal detection bias

For the reality monitoring task, a highly significant difference emerged between the hallucinating and non-hallucinating group on the delayed source discrimination measure $F(1, 36)=9.3, p<0.005$. For immediate source discrimination, this difference was also significant, $F(1,39)=2.9, p<0.05$. The groups did not differ on the recognition parameters $D_1$ and $D_2$. Thus, although patients with hallucinations made more source confusions, there was no differential sensitivity for self-generated or experimenter presented items. Table 2 lists the parameters for the source monitoring task.

Performance of hallucinating patients was indistinguishable from non-hallucinating patients on the non-parametric index of response bias in the detection task. That is, patients with hallucinations were not more willing to indicate they had heard a particular word in the white noise when that word was not actually present. Moreover, the groups did not differ in number of false alarms on the perception interaction tasks.
Table 2. Reality monitoring parameters for the two groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Patients with hallucinations</th>
<th>Patients without hallucinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate ACSIM</td>
<td>0.93 (0.08)</td>
<td>0.97 (0.05)</td>
</tr>
<tr>
<td>Delayed ACSIM</td>
<td>0.85 (0.12)</td>
<td>0.90 (0.12)</td>
</tr>
<tr>
<td>Imm. D₁</td>
<td>0.61 (0.28)</td>
<td>0.55 (0.27)</td>
</tr>
<tr>
<td>Imm. D₂</td>
<td>0.90 (0.13)</td>
<td>0.87 (0.13)</td>
</tr>
<tr>
<td>Del. D₁</td>
<td>0.42 (0.34)</td>
<td>0.30 (0.38)</td>
</tr>
<tr>
<td>Del. D₂</td>
<td>0.91 (0.12)</td>
<td>0.68 (0.86)</td>
</tr>
</tbody>
</table>

¹N for the different analyses: 20/22 for the immediate measures and 18/21 for the delayed measures

Imagery-perception comparisons

Table 3 shows means (and SDs) for the imagery-perception comparison measures. No between-group differences emerged from the MANCOVA on the four imagery-perception comparison measures (F<1, p>0.20). A 2 × 2 ANCOVA with modality as within-subjects factor with two levels (auditory, visual) also failed to show Group × Modality interactions. In addition, a subgroup analysis in which patients with hallucinations (N=17) were contrasted with patients that had never experienced hallucinations (N=9) neither revealed between-group differences.

Imagery-perception interactions

For the auditory imagery-perception interaction task we observed the predicted gain due to imagery. That is, stimuli that had been imaged were detected significantly better than stimuli that had not previously been imaged, t=4.8, p<0.001. However, there was no group difference in the effect of imagery on perception, F(1,33)=2.01, p<0.20.

For the visual imagery-perception interaction task, we failed to replicate the typical imagery gain (e.g., reported by Farah, 1989). This is essential to the validity of the task, as the task can not be said to measure imagery-perception interaction when no influence of imagery on perception is found. Therefore, we will not further discuss this task. (There were no group differences in performance on this task, F<1, p>0.50.)
Table 3. Means (and SDs) for perception minus imagery performance on the imagery-perception comparison tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Patients with hallucinations</th>
<th>Patients without hallucinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory triad comparison</td>
<td>2.4 (3.1)</td>
<td>3.2 (2.2)</td>
</tr>
<tr>
<td>Visual triad comparison</td>
<td>2.8 (1.8)</td>
<td>2.2 (1.8)</td>
</tr>
<tr>
<td>Musical imagery</td>
<td>5.1 (10.4)</td>
<td>4.5 (8.7)</td>
</tr>
<tr>
<td>Letter imagery</td>
<td>9.8 (10.4)</td>
<td>13.0 (18.2)</td>
</tr>
</tbody>
</table>

Due to practical problems not all tasks could be administered to some patients. Therefore the N was as follows: 20/23, 20/23, 18/19 and 17/18, respectively.

Discussion

The aim of the present study was twofold. First, to replicate the finding of reality monitoring errors in patients with hallucinations. Second, to test the “vivid mental imagery” hypothesis of hallucinations in schizophrenia, which states that mental images have more percept-like characteristics in hallucinating individuals. Our finding of source discrimination errors associated with hallucinations is consistent with a range of earlier studies on this subject (Bentall et al., 1991; Böcker et al. 2000; Morrison & Haddock, 1997; Brébion et al., 2000; Franck et al., 2000).

Although the finding of increased reality monitoring deficits in patients with hallucinations is usually taken to imply that biases in reality monitoring lead to hallucinations (Bentall, 1990), it has also been argued that reality monitoring errors are a consequence rather than a cause of psychotic experiences (Vinogradov et al., 1997; Hoffman et al., 2000). According to this account, patients develop an external attribution bias as an explanation for the overwhelming, emotional demanding and confusing abnormal perceptual/cognitive experiences of psychosis. Detailed longitudinal investigations in large patient groups are necessary to clarify the causal direction of reality monitoring errors in relation to hallucination.

Brébion et al. (1997 ; 2000) have pointed out that the term reality monitoring/discrimination can refer to different types of distinctions. For example, between actual events and non-events (i.e., perception vs. imagery) one on the other hand, and between self- and non-self-generated events on the other hand. In this study we found evidence that patients with hallucinations primarily differ from patients without hallucinations on the latter dimension (tapped by the reality monitoring task). In contrast, no differences were observed on
discrimination bias in two signal detection tasks. Such discrimination biases (of the false alarm type) would reflect difficulties in distinguishing between actual and non-events. The lack of group differences on this measure is at odds with results reported by Bentall & Slade (1985) and Brébion et al. (1997), but is consistent with Böcker et al. (2000). The discrepancy may be explained by the fact that our task was identical to the one applied by Böcker et al. (2000), but differed from the tasks applied by Bentall & Slade (1985) and Brébion et al. (1997). More specifically, in the task of Bentall & Slade (1985) only one word was included, which could be present (in white noise) or absent (only white noise). In contrast, in our task a subject was asked to indicate whether a particular word was present in the noise (with different words being presented in the noise). Thus, the discrimination in our task was “same” versus “different”, whereas in Bentall & Slade’s task the discrimination concerned “present” or “absent”. Although both tasks measure the willingness of a subject to admit having heard a word that was not actually presented, Bentall & Slade’s task might more explicitly concern the distinction between material of internal and external origin.

The imagery hypothesis starts from the assumption that, in normal conditions, mental images are less vivid, i.e. have less sensory and contextual characteristics, than percepts. Kosslyn et al. (1999) and Aleman et al. (2000) recently provided evidence for this assumption in non-psychiatric samples. According to the theory of Johnson & Raye (1981) increased vividness of images will make them less distinctive from percepts, which may lead to reality monitoring errors. To test the imagery hypothesis, we investigated whether patients with hallucinations would show smaller differences in performance on imagery and perception conditions of the same task, after controlling for non-specific attentional variables.

For all four behavioral measures, no differences were observed between the hallucinating and non-hallucinating groups. This is consistent with our earlier findings in hallucination-prone individuals (Aleman et al., 2000). If cognitive alterations are associated with hallucinations as a trait (the disposition towards hallucination), our findings could be obscured by the fact that a number of patients in the non-hallucinating group had actually experienced hallucinations in the past (although this had to be more than three months before the study). Therefore, we conducted an analysis in which a subgroup of patients that had never hallucinated was contrasted with the hallucinating group. However, again no significant differences emerged on measures of imagery and perception. Neither were differences observed for imagery-perception interaction. The results
Reality monitoring and mental imagery

corroborate earlier studies by Böcker et al. (2000) and Evans et al. (2000), who also failed to find between-group differences on multiple measures of imagery. However, Böcker et al. (2000) in addition observed more vivid auditory than visual imagery in hallucinating patients on an imagery-perception interaction task. We were not able to replicate this finding, which may be due to the fact that our visual imagery-perception interaction task failed to show the characteristic imagery-gain which is a prerequisite to the validity of the task. However, our other tasks did not show evidence of within-group modality differences.

In conclusion, the present study observed reality monitoring deficits in patients with hallucinations, but no abnormalities were found in imagery-perception relations. Thus, the present results strongly suggest that patients with hallucinations do not have a trait-like alteration of mental imagery that may eventually lead to the emergence of hallucinations. It could be hypothesized, however, that increased vividness of imagery is strictly confined to the hallucinatory state, i.e. occurs only during the actual experience of hallucinations. Indeed, evidence from a case-study of a continuous hallucinating patient suggests that transient, state-dependent alterations in vividness of imagery may play a role in hallucinations (Aleman et al., submitted; see chapter 14). We recommend future research to investigate this more extensively. In addition, research may concentrate on possible interactions between reality monitoring and abnormalities in perception (cf. McKay et al., 2000) or top-down perceptual expectations (cf. Grossberg, 2000).
References


Seitz PFD, Molholm HB (1947) Relation of mental imagery to hallucinations. *Archives of Neurology and Psychiatry* 57:469-480.


