Motor Imagery in Hypnosis: Accuracy and Duration of Motor Imagery in Waking and Hypnotic States

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MOTOR IMAGERY IN HYPNOSIS:
Accuracy and Duration of Motor Imagery in Waking and Hypnotic States

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Abstract: This study assessed response times and accuracy of motor imagery in waking and hypnotic states and to related responses to hypnotic experiences. The Vividness of Motor Imagery Questionnaire (VMIQ) was administered to 47 participants. A mental walking task was then performed in the waking state. In hypnosis, the same task was included within an imaginary journey after a hypnotic induction. An interaction effect showed for condition (waking vs. hypnotic) and distances. The further the participants had to walk in imagination, the longer they took. For all combinations, participants took significantly longer in hypnosis ($p < .001$) and were significantly less accurate in reproducing the difference between the different distances ($p < .001$). Results appear to show a relationship between motor imagery and hypnotic responding and support a state-trait conception of imagery.

In the literature, researchers agree that hypnosis and imagination should, in theory, be related (Farthing, Venturino, & Brown, 1983; Kirsch & Council, 1992). Sarbin and Coe (1972) even describe hypnotic phenomena as “believed-in imaginings” (p. 112). Induction procedures and hypnotic suggestions instruct participants to imagine experiences and actions as real events. Without imaginative involvement, the efficacy of hypnosis seems unthinkable.

Although imagery is implicated in hypnotic techniques, empirical findings are controversial. Relationships between various aspects of...
imagery and hypnotizability mostly departed significantly from linearity. Vivid imagers were both low and highly hypnotizable, whereas those with poor imagery tended to be nonresponsive (Comey & Kirsch, 1999; Hilgard, 1970/1979; Spanos, 1991; Sutcliffe, Perry & Sheehan, 1970; Van Dyne & Stava, 1981). Others who have used Betts Questionnaire Upon Mental Imagery (Betts, 1909) found higher imagery in high hypnotizables (Page, 1998) or no relationship at all for imagery and hypnotic susceptibility (Perry, 1973). Kogon et al. (1998) used computer-generated spatial imagery tasks to measure the ability to generate, maintain, and transform images. The less hypnotizable participants made twice as many mistakes in the spatial imagery tasks than the more hypnotizable participants.

Defined as internal simulation of movements (Papaxanthis, Schieppati, Gentili, & Pozzo, 2002), motor imagery should be of particular relevance for hypnosis. Classic trance induction procedures use movement images to induce (e.g., arm levitation) or images like descending steps to enhance trance depth (Bongartz & Bongartz, 2000). However, imagery in this modality has hardly been researched—most studies concentrated on visual imagery (Roelofs, Hoogduin, & Keijsers, 2002). Glisky, Tataryn, and Kihlstrom (1995) conducted the only known study that directly assessed the importance of motor imagery for hypnosis. They used a test battery that included the Vividness of Movement Imagery Questionnaire (VMIQ; Isaac, Marks, & Russell, 1986) and the Harvard Group Scale of Hypnotic Susceptibility:A (HGSHS:A; Shor & Orne, 1962). Correlations of hypnotizability with motor imagery were negligible and motor imagery did not predict performance on the motor items of the HGSHS:A. The authors suggest that their findings could be a methodical artifact: The self-report measures used in this study are susceptible to subjective biases.

The same criticism applies to most studies in this field: imagery was mainly assessed with self-report questionnaires prior to hypnosis. Such self-reports measure traits that are relatively stable over time. It could be argued that interaction with the hypnotic situation leads to enhanced imagery—a state imagery—only in some individuals, whereas others do not reach this state of high imagery irrespective of their trait imagery. Methods developed in the field of cognitive neuroscience can be helpful in overcoming these problems. These new approaches to motor imagery focus on the underlying brain mechanisms of motor imagery rather than relying on subjective reports (Jeannerod & Frak, 1999).

The mental chronometry paradigm has been widely used to assess motor imagery (Papaxanthis, Pozzo, Skoura, & Schieppati, 2002). Durations of actual and imagined movements in studies using this paradigm were strictly related (Decety, Jeannerod, & Prablanc, 1989). Decety and Jeannerod (1996) conducted a study to investigate mentally
simulated actions in a virtual reality environment. Participants were instructed to imagine themselves walking in a three-dimensional virtual environment toward gates of different apparent widths placed at three different apparent distances. There was a combined effect on response time of both gate width and distance. Duration increased for decreasing gate widths. This result agrees with central motor rules and has been replicated in numerous studies (Papaxanthis, Schieppati, et al., 2002).

For the present study, the following conclusions could be drawn from these findings: Motor imagery measured with self-reports did not show any relevance for hypnotizability. So far, no one has compared objective performance in a waking state with objective performance in hypnosis. Isomorphism of actual and imagined movements simplifies objective measurement of motor imagery: duration and accuracy can act as a direct mirror of imagery processes. Participants who are able to integrate additional effort in motor imagery should more accurately simulate the ratio between different distances in their imagined response times.

The aim of this study was the application of the mental chronometry paradigm in waking and hypnotic states. The central question of our experiment was how response times and accuracy of mental walking tasks differ in the two states of consciousness. We further analyzed to determine whether the performance of the motor tasks differed for participants with high versus low motor imagery as measured with the VMIQ. Due to the explorative character of this study, no additional control group was included within the design. Finally, correlations between objective parameters (response times and accuracy), self-reported imagery, and subjective experiences such as trance depths and vividness of images in hypnosis were investigated. These variables, which are assessed after hypnosis, are more direct images of the actual hypnotic experience than the hypnotizability scales that are usually applied before an experiment. However, as a covariate hypnotic susceptibility was assessed before the experiment.

**METHOD**

**Sample**

Forty-seven right-handed participants volunteered to participate in this study, 34 of whom were included in the following analyses. The rest had to be excluded because they did not always follow the instructions of the motor-imagery tasks in hypnosis. A lack of compliance, boredom, as well as depth of trance could have been reasons for these omissions. However, since it was impossible to assess objectively if and how long these excluded participants mentally walked in their imagination, they could not be included. The remaining participants
were 20 women and 14 men. Average age was 25.68 years ($SD = 7.68$, range = 32). Students made up 58.8 % of the group; the rest of the participants were working in the fields of health care and accounting.

**Design and Independent Variables**

A mixed factorial design was applied with the between-factor self-reported imagery (high vs. low) and the within-factor condition (waking vs. hypnotic). The latter is a repeated-measures factor with different levels (combination of distances / gate widths in mental walking tasks). As a covariate, hypnotic susceptibility was measured.

**Vividness of Motor Imagery Questionnaire.** The VMIQ contains 24 movement imaginations. Vividness of motor imagery is assessed on a 5-point Likert-type scale. High scores represent low vividness of motor imagery. Test-retest reliability was $r = .76$ (3-week interval) (Isaac et al. 1986), and $r = .64$ to $r = .80$ (2-week interval) (Eton, Gilner, & Munz, 1998). Our sample reached a mean score of 106.45 ($M = 99.00$, $SD = 34.00$). Participants were divided into two groups (high vs. low imagery) according to a median split in the VMIQ.

**Mental walking tasks in the waking condition.** The design used by Decety and Jeannerod (1996) was replicated with our equipment. Participants first engaged in a computerized “virtual reality” task in which they simulated, using arrow keys, walking down three tunnels of three different distances (9 m, 6 m, 3 m), they had to walk through gates of 1-m, 2-m, or 3-m width, making a total of nine conditions. The nine conditions were each practiced three times in a randomized order—a total of 27 test-trials were performed. The computer game Half-Life (Sierra©) was used to construe the virtual environment. The same task was then repeated in imagination. Participants were signaled when to commence each of the nine task conditions, and they indicated when they had exited the gate each time. Participants were verbally instructed which tunnel to imagine (e.g., “The next tunnel is 9 m long, the gate at the end is 1-m wide. Please start walking when you hear the signal.”). Every length/gate combination was again presented three times in random order, which means 27 response times could be averaged per person.

**Mental walking tasks in the hypnotic condition.** In the hypnotic condition, the same task was integrated on a CD spoken by a qualified hypnotherapist (recorded and mastered with CoolEdit©). Again, participants could first familiarize themselves with the tunnels in the virtual set-up. After a classic hypnotic induction (10 steps down) there followed an imaginary journey during which participants were asked to imagine walking through tunnels of the same lengths and gate widths as in the waking condition. According to classic hypnosis techniques, the hypnotic anecdote appealed to all senses. The same
instructions as in the waking condition were given for each tunnel. As a start signal, a deep soft gong was used. The sound of the gong was classified as relaxing and agreeable in 10 pretrials. Again, participants were requested to lift a finger whenever they reached the end of a tunnel. If they failed to lift a finger within 60 seconds, the CD continued automatically. Total length of the CD was about 45 minutes, depending on the response times of the participants. The advantage of a CD compared to live hypnosis through the experimenter was seen in the higher degree of standardization of the experimental situation. Furthermore, CDs proved effective in studies about the induction of hypnosis (e.g., Scholz, 2001).

**Dependent Variables, Covariate and Control Variables**

Dependent variables were the response time (RT) between the go signal and the motor signal of the participants in both conditions and the accuracy in the mental walking tasks. RTs of mental walking were acquired with a stopwatch (time resolution 10 ms). An index of accuracy for each distance and each gate width walked in imagination was calculated. This index was based on the three possible ratios of the distance/gate pairs when the numerator was always the larger of the pair (distance: $9m/3m$, $6m/3m$, and $9m/6m$; gate width: $3m/1m$, $2m/1m$, and $3m/2m$). These ratios were presumed to represent accurate performances. For example, the participants should take three times as long when imagining walking 9 m than when walking 3 m. Subtracting the underlying ratios (3, 2, and 1.5) led to a measure showing the deviation of every person from the correct ratio between the tunnels. A score of zero indicates perfect simulation of the difference between the distances, a score below zero shows an underestimation, and a score above zero shows an overestimation of this difference. A similar measurement was used in other studies (Kohl, Fisicaro, Roenker, & Turner, 1998).

Hypnotic susceptibility as assessed by the German version of the Creative Imagination Scale was included as a covariate in the analyses of variance.

_Freyberger Imagination, Relaxation, and Suggestibility Test (FIRST)._ This test (Scholz, 2002) represents an advanced and extended German version of the Creative Imagination Scale (CIS; Barber & Wilson, 1979). Four subscales evaluate relaxation, imagination, and hypnotic suggestibility. Through direct and indirect hypnotic techniques, images (arm levitation, pain insensitivity, etc.) are evoked through a standardized CD (30 minutes). Participants evaluate the vividness of these images by indicating the degree to which the imagined experience was “the same” as if it had occurred in reality. Reliability for all subscales was satisfactory with Cronbach’s alpha between .68 and .81. A combination of self-rated imagery vividness and suggestibility (reactions classified by the experimenter) was used for the analyses.
To assess subjective experiences of the two experimental groups (high vs. low imagery), the following questionnaires were administered after hypnosis.

*Field’s Inventory Scale of Hypnotic Depth.* This scale (Field, 1965) measures hypnotic depth by means of self-reported experiences like sleepiness, distraction, concentration, etc. It contains 38 items with statements that have to be answered dichotomously with regard to their occurrence. The author reports a test-retest reliability of $r = .87$.

*Relaxation Experiences Questionnaire (REQ).* The REQ (Csákó & Mészáros, 2002) is a self-report measurement designed to assess altered states. Participants indicate on a seven-point Likert-type scale how they experienced the following: relaxation, visual and motor imagination (RESmot), gustatory and haptic imagery, attentional alterations, and depth. An altered-state index is calculated from the total score. According to the authors, internal reliability was .82.

**EXPERIMENTAL PROCEDURE**

Two meetings were held with every subject. During one meeting, the VMIQ, the FIRST and the awake mental walking tasks were applied in random order to avoid order effects. Participants were sitting in a relaxation chair while performing the tasks in their imagination. The experimenter was in the same room while presenting the different tasks verbally. This meeting lasted for approximately 45 minutes. During the other meeting, participants listened to the hypnosis CD, which contained the same mental walking tasks as in the awake condition. Subsequently, they answered the additional questionnaires about their subjective experiences during the hypnosis (Field’s; REQ). Participants were alone in an experimental room while listening to the CD. They were sitting in a relaxation chair and were informed that the experimenter would observe their reactions through a one-way mirror. This meeting lasted approximately 1 hour, depending on the RTs of the participants. The sequence of the two meetings was balanced, and they always took place on different days to avoid sequence effects and effects due to participant fatigue. Figure 1 shows the experimental protocol of this study.

**Data Analyses**

Analyses of variance were performed to determine (a) differences between RTs and accuracy of motor imagery in awake and hypnotic states; (b) differences between low and high imagers according to the VMIQ awake and in hypnosis; (c) correlations between objective parameters (RTs and accuracy), self-reported motor imagery, hypnotizability, and subjective experiences. Statistical analyses were conducted with SPSS 11.0 package.
RESULTS

Response Times and Accuracy of Motor Imagery in Awake and Hypnotic States

Mean absolute RTs differed significantly ($\text{ME}_{\text{awake}} = 4.25 \pm 2.11$; $\text{ME}_{\text{hyp}} = 10.06 \pm 3.12$, see Table 1) between the two conditions. In hypnosis, participants took on average 2.11, 2.46, and 2.77 times longer for the three distances than in the awake condition. A comparison of the mean RTs with a repeated measures ANOVA with the within-factor condition (awake vs. hypnotic) and its distance of mental walking task (3 m vs. 6 m vs. 9 m) showed that differences in mean RTs were significant between all distances. Main effects for condition, $F(1, 33) = 112.82, p < .001$, and for distance, $F(2, 66) = 66.13, p < .001$, were highly significant, as was the two-way interaction between condition and distances, $F(2, 66) = 7.21, p < .01$. A post hoc Scheffé test confirmed the relevance of the reported effects ($p < .001$ for all comparisons). As can be seen in Figure 2 in both conditions, distance was correctly integrated in the imaginary walking. The further the participants had to walk in imagination, the longer they took, but for all lengths the hypnotized participants took considerably
Table 1
Results of ANOVAs of Mental Walking Tasks Waking and in Hypnosis

<table>
<thead>
<tr>
<th>Factor:</th>
<th>Response Times</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response Times</td>
<td>M ± SD</td>
<td>F</td>
</tr>
<tr>
<td>Condition</td>
<td>waking: 4.25 ± 2.11</td>
<td>44.23</td>
</tr>
<tr>
<td></td>
<td>hyp: 10.06 ± 3.12</td>
<td>17.63</td>
</tr>
<tr>
<td>Levels:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>3 m: 4.46 ± 1.14</td>
<td>39.20</td>
</tr>
<tr>
<td></td>
<td>6 m: 7.35 ± 2.00</td>
<td>39.20</td>
</tr>
<tr>
<td></td>
<td>9 m: 10.52 ± 3.76</td>
<td>39.20</td>
</tr>
<tr>
<td>Gate width</td>
<td>1 m: 8.32 ± 2.58</td>
<td>11.15</td>
</tr>
<tr>
<td></td>
<td>2 m: 6.67 ± 1.99</td>
<td>11.15</td>
</tr>
<tr>
<td></td>
<td>3 m: 7.00 ± 1.86</td>
<td>11.15</td>
</tr>
<tr>
<td>Condition × Distance</td>
<td>16.82</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Condition × Gate Width</td>
<td>10.30</td>
<td>p &lt; .001</td>
</tr>
</tbody>
</table>
longer. The covariate hypnotizability did not contribute to overall variability ($p > .05$).

For the different gate widths, repeated measures ANOVAs also reached significance, indicating that gate widths influenced RTs. Main effects were significant for condition, $F(1, 33) = 107.69, p < .001$, and for gate widths, $F(2, 66) = 17.95, p < .001$. Again, the two-way interaction was highly significant, $F(2, 66) = 16.27, p < .001$. Scheffé tests showed that differences between the waking and the hypnotic conditions were all relevant (all comparison $p < .001$). Within the awake condition, however, the correct differences between the gate widths were not replicated; post hoc Scheffé tests did not show relevant effects. In hypnosis, participants took considerably longer to mentally negotiate the narrowest gate (1 m) than the other two (Scheffé tests $p < .001$ for 1 m gate). Gate widths were not reflected as correctly as distances in the RTs in either condition. Again, the covariate hypnotizability did not contribute to overall variability ($p > .05$).

As described above, deviations from the ratio between the distances were calculated next as an objective measurement of accuracy. As shown by a repeated measures ANOVA with the factor condition (awake vs. hypnotic) and ratios between distances ($9m/6m$ vs. $9m/3m$ vs. $6m/3m$), the

Figure 2. Response times for the mental walking tasks in two experimental conditions (awake vs. hypnosis) are presented. Three gates of different widths (3 m, 2 m, and 1 m) were placed at three different distances (9 m, 6 m and 3 m). Participants were asked to imagine walking through the gates at the end of the tunnels.
accuracy differed between waking versus hypnotic, as the main effect for condition was highly significant, $F(2, 66) = 56.64, p < .001$. A main effect for ratio, $F(1, 33) = 17.64, p < .001$, and the two-way interaction between condition and ratio were also significant, $F(2, 66) = 6.84, p < .001$. Scheffé’s tests showed that the difference between 9 m and 3 m was underestimated significantly more than the difference between the other distance combinations (comparisons for $9^m/3^m$ awake and in hypnosis, $p < .001$). Participants were less accurate in hypnosis and were less accurate the greater the difference between two distances was. The covariate hypnotizability showed no effect on overall variability ($p > .05$).

As can be seen in Figure 3, participants were even less accurate in simulating the difference between the gates than the difference between the distances. Otherwise, results could be replicated for the factor condition (awake vs. hypnotic) and the ratios between gates ($3^m/2^m$ vs. $3^m/1^m$ vs. $2^m/1^m$). Accuracy differed between the two conditions for the three gates. Main effects, condition, $F(1, 33, = 14.68, p < .001$; ratio, $F(2, 66) = 1155.62, p < .001$, as well as the two-way interaction, $F(2, 66) = 6.84, p < .001$, were highly significant. Scheffé’s post hoc test confirmed that all effects were relevant (all comparisons $p < .001$). In hypnosis, participants were less accurate than when awake. The covariate hypnotizability reached significance for gate widths ($p = .05$).

**Figure 3.** The accuracy of response times in the mental walking tasks for two experimental conditions (awake vs. hypnosis) is shown. The accuracy indices are based on the three possible ratios between the distances/gate-widths pairs (distances: 9 m/6 m, 6 m/3 m, and 9 m/3 m; gates: 3 m/2 m, 2 m/1 m, and 3 m/1 m). The resulting ratios (3, 2, and 1.5) are presented in brackets (see text for description of method).
Individuals with higher scores were less accurate (Scheffé post hoc tests, all comparisons $p < .001$).

Regarding accuracy, it can be recapitulated that participants underestimated the effects of increasing distance or decreasing gate width on walking times. Furthermore, the accuracy depended on the ratio between the gate widths: the smaller the difference between the given gates, the more accurately they could simulate it. In hypnosis, participants were generally less accurate. Results of all ANOVAs are presented in Table 1. Hypnotizability was included as a covariate in the analyses of variance to determine its contribution to overall variability of RTs and accuracy, both waking and in hypnosis. In Table 2, the effects of this covariate are combined. As can be seen, hypnotizability-only affected the accuracy in simulating the difference between the different gate widths: participants with higher underlying hypnotic susceptibility were less accurate.

**Differences Between Low and High Imagers According to the VMIQ**

Participants were divided into two groups according to a median split in the VMIQ. As shown in Table 3, participants with high imagery in this questionnaire showed a tendency to take longer for the mental walking tasks in both conditions. However, results did not reach statistical significance in a one-factorial ANOVA with the factor motor imagery (high vs. low). Both groups generally took longer in hypnosis than in the awake condition. The groups did not differ regarding the accuracy of their performance of the mental walking tasks. No interaction or main effect of the covariate hypnotizability could be shown.

One-way ANOVAs were also used to analyze differences between the two experimental groups with regard to the additional variables included in the experimental design. As shown in Table 4, the questionnaire scores differed significantly for participants with high vs. low motor imagery according to the VMIQ. Participants with high imagery reached higher scores on all questionnaires. They showed higher trance depth (Field’s), more vivid imagery in hypnosis (REQ), and higher hypnotizability according to the FIRST.

**Correlations Between Objective Parameters (RTs and Accuracy), Self-Reported Motor Imagery, Hypnotizability, and Subjective Experiences**

We calculated Pearson’s product-moment correlations between all measures applied in this study to analyze possible relationships between the other variables and motor imagery both as assessed in the mental walking tasks and according to the VMIQ. Interestingly, only the waking accuracy correlated with waking RTs but not accuracy and RTs in hypnosis. The accuracy waking and in hypnosis did correlate moderately, as can be seen in Table 5. Pearson’s product-moment
Table 2
Contribution of the Hypnotic Susceptibility Covariate to Overall Variability

<table>
<thead>
<tr>
<th></th>
<th>Response Times</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance</td>
<td>Gates</td>
</tr>
<tr>
<td>Low susceptibility*</td>
<td>M: 7.25</td>
<td>M: 7.18</td>
</tr>
<tr>
<td></td>
<td>SD (0.54)</td>
<td>SD (0.55)</td>
</tr>
<tr>
<td>High susceptibility*</td>
<td>M: 7.07</td>
<td>M: 7.08</td>
</tr>
<tr>
<td></td>
<td>SD (0.51)</td>
<td>SD (0.52)</td>
</tr>
<tr>
<td>ANOVA</td>
<td>F(1, 32, 99%) = 0.05</td>
<td>F(1, 32, 99%) = 2.66</td>
</tr>
<tr>
<td></td>
<td>p = .81</td>
<td>p = .89</td>
</tr>
</tbody>
</table>

*Hypnotic susceptibility was measured with the Freyberger Imagination, Relaxation, and Suggestibility Test (FIRST).
Table 3
Performance of the Two Experimental Groups (Low vs. High Motor Imagery)

<table>
<thead>
<tr>
<th>VMIQ</th>
<th>Response Times</th>
<th></th>
<th>Accuracy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Awake</td>
<td>Hypnosis</td>
<td>Awake</td>
<td>Hypnosis</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>(SD)</td>
<td>M</td>
<td>(SD)</td>
</tr>
<tr>
<td>low imagery</td>
<td>3.91</td>
<td>(2.08)</td>
<td>9.91</td>
<td>(2.82)</td>
</tr>
<tr>
<td>high imagery</td>
<td>4.56</td>
<td>(2.16)</td>
<td>10.20</td>
<td>(3.45)</td>
</tr>
<tr>
<td>total</td>
<td>4.25</td>
<td>(2.11)</td>
<td>10.06</td>
<td>(3.12)</td>
</tr>
<tr>
<td>(factor VMIQ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>F(1, 32, 99%) = .79</td>
<td>p = .38</td>
<td>F(1, 32, 99%) = .07</td>
<td>p = .78</td>
</tr>
</tbody>
</table>
Table 4
Subjective Experiences and Hypnotic Susceptibility of the Two Experimental Groups

<table>
<thead>
<tr>
<th></th>
<th>FIRST</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMIQ low imagery</td>
<td>18.44 (6.61)</td>
<td>37.75 (9.39)</td>
<td>3.31 (1.66)</td>
<td>10.19 (5.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMIQ high imagery</td>
<td>25.06 (5.93)</td>
<td>45.94 (5.97)</td>
<td>4.72 (1.80)</td>
<td>14.00 (4.87)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANOVA (factor VMIQ)</td>
<td>F(1, 32, 99%) = 9.46</td>
<td>F(1, 32, 99%) = 9.43</td>
<td>F(1, 32, 99%) = 5.55</td>
<td>F(1, 32, 99%) = 4.93</td>
<td>p &lt; .01</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>M in the Literature*</td>
<td>20.45</td>
<td>44.33</td>
<td>--</td>
<td>14.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*See Method section for references. FIRST = Freyberger Imagination, Relaxation, and Suggestibility Test; REQ = Relaxation Experiences Questionnaire, REQmotor = Item motor imagery of the REQ; and FIELD = Field Inventory Scale of Trance Depth.
Table 5
Pearson’s Product Moment Correlations of all Measurements

<table>
<thead>
<tr>
<th></th>
<th>VMIQ</th>
<th>REQ</th>
<th>REQ motor</th>
<th>FIELD</th>
<th>FIRST</th>
<th>Acc. Awake</th>
<th>Acc. Hyp</th>
<th>Resp. Awake</th>
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</thead>
<tbody>
<tr>
<td>REQ</td>
<td></td>
<td>0.42**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ motor</td>
<td>−0.30</td>
<td></td>
<td>0.42**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIELD</td>
<td>−0.13</td>
<td>0.64**</td>
<td></td>
<td>0.38*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRST</td>
<td>0.35*</td>
<td>0.62**</td>
<td>0.67**</td>
<td>0.61**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acc. Awake</td>
<td>−0.14</td>
<td>0.06</td>
<td>0.02</td>
<td>0.14</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acc. Hyp</td>
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<td>0.01</td>
<td>0.03</td>
<td>0.31</td>
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<td>Resp. Awake</td>
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<td>−0.11</td>
<td>−0.28</td>
<td>−0.19</td>
<td>−0.06</td>
<td>0.41*</td>
<td>0.31</td>
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<tr>
<td>Resp. Hyp</td>
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<td>0.01</td>
<td>0.12</td>
<td>0.16</td>
<td>0.21</td>
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*p < .05, **p < .001.

VMIQ = Vividness of Movement Imagery Questionnaire; REQ = Relaxation Experiences Questionnaire; REQ motor = Item motor imagery of REQ, FIELD = Field’s Inventory Scale of Trance Depth; FIRST = Freyberger Imagination, Relaxation, and Suggestibility Test; Acc. Awake = accuracy in mental walking tasks awake; Acc. Hyp = accuracy in mental walking tasks in hypnosis; Resp. Awake = response times in mental walking tasks awake; and Resp. Hyp. = response times in mental walking tasks in hypnosis.
correlations revealed that neither RTs nor accuracy correlated with the self-report questionnaires, because none of the correlations reached significance. The VMIQ also did not correlate significantly with the objective measures of motor imagery in the hypnotic or waking conditions.

**DISCUSSION**

The aim of this study was to investigate the differences in RTs and accuracy of motor imagery between waking and hypnotic states. We assumed that by using mental walking tasks that are more objective than self-reports, we would find a strengthened relationship between motor imagery and hypnosis. Results support a state-trait concept of motor imagery in hypnosis: Substantial differences between waking and hypnotic states could be found. Participants took longer and were less accurate in hypnosis than when waking.

The difference between the distances was correctly reflected in RTs for both conditions. This effect could not be found for gate widths. This finding partly contradicts Decety and Jeannerod (1996), who found a linear influence of gate widths on RTs. However, in their study, the subjective sense of effort increased with distance but was not affected by gate widths. The same dissociation between actual RTs and subjective effort possibly resulted in the lack of effects for gate widths in our study. Increasing effort might not have been perceived by the participants, because the narrowest gate (1 m) would be easily manageable in actual walking tasks and would still not present a real obstacle.

In hypnosis, participants took 2.11 to 2.77 times longer for the mental walking than in the waking condition. Time distortion—especially underestimation—is a well-known phenomenon in hypnosis (Kirchenheim & Persinger, 1991). Underestimation of time agrees with the longer RTs in hypnosis in this study. Possibly, an interaction between imagination and timing processes leads to this difference between the two conditions. Time distortion presumably depends on absorption in the hypnotic situation (St. Jean & MacLeod, 1983). As the participant becomes absorbed in hypnotic events, little or no attention is paid to the passage of time. Another theory suggests that attention-demanding tasks attenuate time estimation—the so-called busy beaver hypothesis (St. Jean & Robertson, 1986). In a study comparing an attention-demanding set to an absorptive set, underestimation was only significant for the attentional task. For our study, this implies that the attentional demands for the same mental walking task were higher in hypnosis than when waking. In the hypnotic situation, not only the tasks were presented but also a classic hypnosis with demands on all senses. There is, indeed, strong evidence that hypnosis leads to an increase in active attentional processing (Crawford, 1994; St. Jean, McInnis, Campbell-Mayne, & Swainson, 1994; St. Jean & Robertson, 1986). It may well be this
characteristic of hypnosis that mediates the underestimation of time that results in longer RTs for the mental walking tasks in hypnosis.

Furthermore, the longer RTs in hypnosis could be a result of task interference. Tasks that require a considerable amount of effort interfere with the effort needed for hypnotic dissociation and lead to slower performances. Stevenson (1976) argues that the condition of hypnosis requires considerable effort and increases task interference. The hypnosis in itself may be interpreted as a task of attention diversion in which substantial cognitive effort is involved. Arithmetic and color-naming tasks performed during hypnosis showed a deficit over conscious performance in his experiments. It could be argued that motor imagery interfered with hypnotic dissociation in this study, and longer RTs are, therefore, interpretable as a performance deficit.

An alternative interpretation of the considerable difference in RTs could be that the hypnotic induction directly altered how participants performed the mental-imagery task or their expectations of how they were to perform it. The instructions used in both conditions were identical (“Please start walking when you hear the signal”). However, the induction emphasized mental and physical relaxation and possibly encouraged the participants to imagine ambling along at a more leisurely pace than they did in the waking condition.

The analysis of the accuracy of images showed an underestimation of the difference between the distances or gates in both conditions. In hypnosis, participants were even less accurate than in the waking state. Interestingly, the covariate hypnotic susceptibility did only contribute to the accuracy of simulating the different gate widths: high hypnotizables were less accurate. Again, absorption and attention in the hypnotic situation could be factors responsible for this effect.

In the literature, temporal accuracy of motor imagery varied widely across participants but not within participants (Kohl et al., 1998). Our results indicate that accuracy does vary within participants across different situations. What variables, however, could cause this difference of accuracy in waking versus hypnosis? Studies using functional magnetic resonance imaging found activation in the same brain areas for actual and imagined movement (Papaxanthis, Schieppati, et al., 2002). It would be interesting to investigate if different areas are involved during motor imagery in hypnosis. Longer RTs and less accuracy in hypnosis could result from differential activation of central sensorimotor areas or temporal information processing. Papaxanthis, Pozzo, et al. (2002) assume that in the working memory sensory-motor information of a movement is stored and then serves as a calibration reference for the consistent reproduction of actual as well as imagined movements. According to this conception, there should be no difference in motor imagery characteristics, no matter when and under what circumstances such a movement image is reproduced, because the
same memory information will be retrieved for every new image. Therefore, it could be argued that the effects found for the hypnotic condition have to be produced by some other neural process—probably structures involved in timing. These questions should be addressed in future research.

There is an ongoing discussion in the literature as to whether or not vividness of imagery is a stable trait. This controversy emanates from the fact that classic methods only show low stability over time. Test-retest reliability for the VMIQ lies between $r = .64$ and $r = .80$ (Eton et al., 1998). Based on those findings, Ahsen (1987, 1993) questioned if imagery constitutes a stable trait at all. He believes that imagery is a dynamic, situation-dependent process, which would explain why stability over time cannot be expected. This theory is fully supported by our findings about differences between motor imagery in the waking and hypnotic conditions. As Kogon et al. (1998) presumed, “the ability to experience vivid images in a hypnotic state does not necessarily predict the ability to use imagery outside of a hypnotic context” (p. 368).

As demonstrated in numerous studies (see Annett, 1995, for a review), the VMIQ did not correlate with performance in the mental walking tasks. Furthermore, the two extreme groups (high vs. low imagery) did not differ significantly with regard to RTs and accuracy in the mental walking tasks. Group differences showed, however, for the control variables. Generally, participants with high imagery in the VMIQ also reported more motor imagery in hypnosis (REQ), higher trance depths (Field’s), and higher hypnotic susceptibility (FIRST). Common characteristics of self-report measures might cause this relationship between the subjective measures. These measures did demonstrate that the sample used in our study was of average hypnotizability and did reach significant trance depth.

Finally, one major problem of this study should be addressed. The mental walking tasks rely on participants indicating the end of their imagined walk. Thirteen (28%) persons had to be excluded because no observable reaction was shown. These persons could well have been high imagers in deep trance or even bored lows. Their mean scores on the questionnaires were compared to those of the 34 compliant participants. The noncompliant individuals tended to be less hypnotizable (lower scores in the Field’s and FIRST scales). However, these differences were not significant, and their mean score on the VMIQ did not differ at all from the compliant participants (noncompliant: 105.54; compliant: 106.45). The assessment of electrocortical activity during the performance of the motor imagery tasks will be used in a follow-up study to evaluate information processing of these two groups. EEG markers for trance and for imaginative processing (alpha and theta power) could answer the questions of if these noncompliant persons did not engage in the tasks presented and if the compliant participants
used motor imagery throughout the tasks. An increase of occipital alpha power would indicate the use of motor imagery according to Marks and Isaac (1995).

Glisky et al. (1995) assumed that the lack of correlation between imagery and hypnosis in their study could be due to methodological artifacts in concert with self-report measures. We argue that mental walking tasks are a more valid measure of imagery in hypnosis. In this study, we could show the value of the mental chronometry paradigm for the research of imagery processes in hypnosis. It could be demonstrated that objective measures from the field of neuro-cognitive research result in a comprehensible relationship between hypnotic experiences and imagery. Participants showed longer RTs and less accuracy of motor images in hypnosis. Combined with psychophysiological methods, this paradigm promises a new approach to the investigation of cognitive processes in different states of consciousness.

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L’imagerie motrice sous hypnose : précision et durée de l’imagerie motrice en état de veille et sous hypnose.

Brigitte Konradt, Salim Deeb, et Oskar-Berndt Scholz

Résumé : cette étude évalue les temps de réponse et la précision de l’imagerie motrice en état de veille et sous hypnose ainsi que les réponses liées aux expériences hypnotiques. Le ‘Vividness or Motor Imagery Questionnaire’ (VMIQ : questionnaire de netteté de l’imagerie moteur) fut administré à 47 participants. Puis on suggéra une tâche de ‘marche mentale’ en état d’éveil. Sous hypnose, la même tâche fut incluse dans un voyage imaginaire après induction hypnotique. On constate un effet d’interaction pour la condition (éveillé vs. sous hypnose) et les distances. Plus loin les
particiipants devaient marcher en imagination, plus ils fallait du temps. Pour toutes les combinaisons, les participants sous hypnose prenaient sensiblement plus de temps (p < .001) et ils étaient sensiblement moins précis dans la restitution des différentes distances (p < .001). Il semblerait qu’un lien existe entre l’imagerie motrice et les réponses hypnotiques. Ces résultats soutiennent la théorie d’une imagerie liée au modèle « conception-caractéristique-état » (veille vs hypnose).

Brigitte Konradt, Salim Deeb, y Oskar-Berndt Scholz

Resumen: Este estudio evaluó los tiempos de reacción y la exactitud de las imágenes motrices en los estados de vigilia e hipnótico y las respuestas relacionadas con las experiencias hipnóticas. Administramos el Cuestionario de Vividez de Imágenes Motrices (VMIQ) a 47 participantes, quienes tuvieron entonces que ejecutar una tarea mental de caminar en estado de vigilia. En la hipnosis, se incluyó la misma tarea dentro de un viaje imaginario después de una inducción hipnótica. Obtuvimos un efecto de interacción entre la condición (vigilia vs. hipnosis) y las distancias. Mientras más tenían que caminar los participantes en la imaginación, más tiempo tomaban. Para todas las combinaciones, los participantes se tardaron apreciablemente más en hipnosis (p < .001) y fueron apreciablemente menos exactos en hipnosis para reproducir la diferencia entre las diversas distancias (p < .001).