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Do Self-Statements Enhance the Effectiveness of Virtual Reality Exposure Therapy? A Comparative Evaluation in Acrophobia

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ABSTRACT

There is a clear need for more detailed analysis of the role of cognitive self-statements in virtual reality exposure therapy (VRET). To date, no research on this topic has been done. The primary aim of this study was to investigate whether coping self-statements would enhance the effectiveness of VRET. In a randomized crossover design, 26 patients with acrophobia (DSM-IV diagnosis of specific phobia) were randomly assigned to two sessions of VRET followed by two sessions of VRET plus coping self-statements, or the other way around: first two sessions of VRET plus coping self-statements followed by two sessions of VRET. Results showed that VRET, regardless of addition of coping self-statements, decreased anxiety of heights, decreased avoidance of height situations, and improved attitudes towards heights. However, at 6-month follow-up, most gains during treatment were not fully retained.

INTRODUCTION

Exposure therapy is the golden standard in treating clients with specific phobias.[10] Clients are confronted (either graded or by means of flooding) with situations or stimuli that frighten them. When avoidance of these phobic stimuli is prohibited, anxiety will habituate, and the situation will progressively be experienced as more neutral.[13]

Some information is available on the effectiveness of cognitive therapy in the treatment of specific phobias and, more specifically, whether cognitive therapy enhances the effects of exposure *in vivo*. However, results are mixed: some showed that cognitive restructuring was effective as treatment[12] even when compared with exposure *in vivo*.[5,15,24] Others showed that cognitive restructuring was less effective than exposure.[4,20] No conclusions with regards to the effectiveness of cognitive therapy, or exposure *in vivo* plus cognitive therapy for specific phobias can be drawn.

A recent development in behavior therapy of specific phobias is exposure by means of virtual reality (VR). Clients are not confronted with real anxiety-provoking stimuli but with their virtual counterparts. VR integrates real-time computer graphics, body tracking devices, visual displays, and other sensory input devices to immerse patients in a computer-generated virtual environment. Most research on virtual reality exposure therapy (VRET) as standalone treatment is based on case studies. In the last few years, more randomized, controlled effectiveness studies have been conducted, and their results support the effectiveness of VRET. It has been

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shown that exposure by means of VR is more effective than a waiting period for (1) fear of flying,[19,25,27] (2) acrophobia,[18,26] and (3) claustrophobia,[6] Moreover, VRET was found to be as effective as exposure *in vivo* for acrophobia.[14,16]

In other research, VRET plus cognitive therapy and anxiety management training (CT and AMT) was evaluated and compared to exposure *in vivo* plus CT and AMT. CT and AMT (four sessions in total for both treatment conditions) consisted of breathing retraining, cognitive restructuring, thought-stopping, and hyperventilation exposure. VRET consisted of exposure to virtual flying, while exposure *in vivo* consisted of exposure to airport stimuli and pre-flying stimuli. There were no differences in effectiveness found between the two treatment programs in fear of flying.[25,27] In a study by Mühlberger et al.,[23] VRET plus CT was compared to CT alone in one long group-session. CT (independent of condition; one session of 60 min) consisted of analyzing thoughts, feelings, and bodily symptoms related to fear of flying; thinking out catastrophic cognitions; and asking questions about the explained concepts of anxiety and exposure. Post-treatment and 6-month follow-up assessments revealed reduced fear of flying only in the VRET group, not in the pure CT group.

Finally, in a study by Maltby et al.,[22] VRET plus AMT was compared to a placebo group training. AMT consisted of education on the safety and mechanics of flying, imaginal relaxation, progressive muscle relaxation, and the development and use of coping self-statements to counter anxiety-provoking thoughts and images about flying. The VRET condition showed superior results to the placebo group on four out of five outcome measures at post-test. However, at 6-month follow-up, most group differences had disappeared. Unfortunately, no studies on VRET plus CT for acrophobic patients have been found.

Results of cognitive restructuring in the above-mentioned studies are difficult to evaluate, since an amalgam of different cognitive techniques and/or anxiety management techniques were used. There is a clear need for more detailed analysis of the role of cognitive techniques in VR exposure. Moreover, a distinction should be made between cognitive and anxiety management techniques, including relaxation techniques. To date, no research has been done in which VRET is compared to VRET plus pure cognitive techniques used during sessions of exposure.

The primary aim of this study is to investigate the effectiveness of VRET and the possible additional effectiveness of cognitive techniques, specifically coping self-statements in patients with acrophobia. In a randomized crossover design, patients with acrophobia were assigned to two sessions of VRET followed by two sessions of VRET plus coping self-statements, or the other way around: first two sessions of VRET plus coping self-statements followed by two sessions of VRET. It was expected that VRET, with or without the addition of coping self-statements, would be effective as treatment of specific phobias. No specific predictions on the possible differences in effectiveness were made, because of inconsistent results of past research on the addition of cognitive techniques to exposure *in vivo*, and scarce information on the addition of pure cognitive techniques to VRET.

METHODS

Design

After an intake session by a clinical psychologist, a pre-test followed, after which subjects were randomly assigned over two conditions: (1) two sessions of VRET, followed by two sessions of VRET plus coping self-statements or (2) two sessions of VRET plus coping self-statements, followed by two sessions of VRET. All sessions were given weekly and took about 1.5 h (1 h of exposure, followed by a 10-min break, and then 20 min to fill in questionnaires). The first cognitive session took half an hour longer to explore idiosyncratic cognitions and create more neutral self-statements. Between sessions 2 and 3, an intermediate test was held. In the week after the last session a post-test was held, and 6 months after treatment a follow-up test was held.

Participants

To participate in this project, subjects had to meet current *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed. (DSM-IV) criteria for a specific phobia, i.e., acrophobia.[2] Subjects were excluded if they met criteria of posttraumatic stress disorder or acute stress disorder (not related to fear of heights), panic disorder, and/or severe agoraphobia. Subjects were also excluded if they had suicidal tendencies, did not want to stabilize their antidepressant medication during the course of treatment, or were unable to discontinue the use of benzodiazepines. For technical reasons, because of the VR equipment, subjects with glasses stronger than 3.5, epilepsy, or pacemakers were also excluded.

Treatment

VRET with a head-mounted display was provided in a dark laboratory room at the Department

of Clinical Psychology of the University of Amsterdam. The virtual worlds were generated using a Pentium-II 450-MHz computer with 128-Mb RAM, 4-Gb hard disk, and a 3D-Labs Oxygen GVX-420 graphics card with 128-Mb video memory and dual-monitor support. The software used was Sense 8 WorldUp R4, a commonly used VR modeling and visualization toolkit. The system was able to generate the display at a rate of about 15–20 frames per second. The worlds were displayed using the Cybermind Visette Pro. The projection was stereographic. The field of view was 70.5 degrees diagonally. Tracking was done with Ascension Flock of Birds.

Three virtual environments (VEs) were created for treatment of fear of heights and were used in a gradual order: a fire escape with six floors in open space, a roof garden on a building, and a virtual building site with eight floors. Patients could walk around freely on one square meter in all height VEs. A railing the patient could hold on to bounded this area.

To give patients a gradual and optimal exposure treatment, patients had to rate their anxiety regularly during the exposure therapy by means of Subjective Units of Discomfort (SUDS), from 0 to 10. Patients were instructed during treatment to expose themselves to the anxiety-provoking situations in a gradual manner. After extinction as evidenced by a relatively low SUD, patients were encouraged to take a next step (for instance, move up one floor).

In the two sessions of VRET-only (or "pure VRET"), exposure was used during treatment; no cognitive intervention or relaxation was provided.

In the two sessions of VRET plus coping self-statements, the rationale of CT was explained briefly, and anxiety-provoking cognitions were examined and more neutral self-statements were formulated (in approximately half an hour). Anxiety-provoking cognitions were already examined during a few minutes of imaginary exposure at intake. These cognitions were written down, and in the first session of coping self-statements, patients were asked if these cognitions were correct and if other anxiety-provoking cognitions bothered them with regards to their acrophobia. All cognitions were written down. Together with the patient, more neutral self-statements were formulated, which could be used during the exposure treatment. During VRET, questions about cognitions of the subjects were asked, and subjects were instructed to use the formulated neutral self-statements during the exposure.

In order to study the effects of pure VRET and/or VRET plus coping self-statements, patients did not receive homework instructions in either condition, and practicing *in vivo* between sessions at home was not encouraged.

Assessment

Intake. The section of anxiety disorders of the Structured Clinical Interview for DSM-IV Axis I disorders (SCID-I)[17] was used in the intake session. The Beck Depression Inventory (BDI)[3] was used to screen for depressive symptoms. In the intake session, imaginal exposure to the most frightening phobic situation of each subject was used to list cognitions that were anxiety inducing and could be used during the first session of VRET plus coping self-statements. This took several minutes.

Pre-test, intermediate test, post-test, and follow-up. Questionnaires were used at pre-test, intermediate test, post-test, and follow-up to evaluate the effectiveness of treatment. There were two main outcome measures: (1) The Acrophobia Questionnaire (AQ)[8] measured anxiety in height situations (range, 0–120; $\alpha = 0.80$) and avoidance of height situations (range, 0–40; $\alpha = 0.70$). (2) The Attitude Towards Heights Questionnaire (ATHQ)[1] assessed the attitudes from the patients towards height situations (range, 0–60; $\alpha = 0.81$).

Within VRET sessions. Questionnaires were also used to measure changes within each treatment session.

A *cognition questionnaire* was developed for fear of heights, based on the cognition questionnaire of agoraphobia.[29] This questionnaire was filled in after every treatment session. Each item was scored on a five-point Likert-type scale ("not at all" to "constantly"). The questionnaires consisted of 24 items with an internal consistency of $\alpha = 0.77$–0.89.

To measure presence during VRET, the *Igroup Presence Questionnaire* (IPQ) was used.[28] Presence is the feeling of being in the VE (i.e., a height situation) instead of the real environment (the therapist office, wearing VR glasses). The IPQ consisted of 14 items that measured the feeling of being in the VE ($\alpha = 0.85$–0.87). Each item was scored on a seven-point Likert-type scale ("totally disagree" to "totally agree").

Subjective units of discomfort (0–10) were rated every 5 min during a session. The first six SUDs were added to evaluate the subjective anxiety by session (range, 0–60).

Statistical analysis

Possible differences in sex distribution, age, BDI scores, and dependent variables between orders at

baseline were analyzed with χ^2 analysis or analysis of variance (ANOVA), when appropriate.

The AQ-anxiety, AQ-avoidance, and ATHQ scores from the crossover trial were analyzed in two stages. In the first stage, an order effect was tested by a main effect of order. Repeated-measures analyses were used for a main effect of time and interaction effects of time by order to test the difference between VRET and VRET plus coping self-statements. Moreover, if multivariate analyses indicated significant results, univariate analyses were run, to examine the effects on separate questionnaires.

To evaluate the stability of change, a repeated-measures analysis was run on the AQ-anxiety, AQ-avoidance, and ATHQ scores between post-test and 6-month follow-up. After multivariate analyses, univariate analyses were used if indicated. The within-group effect sizes of the changes on the AQ-anxiety, AQ-avoidance, and ATHQ were analyzed by computing Cohen's d.[9] Cohen's d is the difference between the two means being compared, divided with their pooled standard deviations. Cohen[9] has suggested that $d = 0.20$ can be considered to indicate a small effect, $d = 0.50$ a medium effect, and $d = 0.80$ a substantial effect.

To evaluate the effects of treatment within sessions, the data on the SUDS, IPQ, and cognition questionnaire were analyzed in two stages. In the first stage, the potential of an order effect was tested by a main effect of order in a repeated-measures analysis. In the second stage, repeated-measures analyses were used to test for possible changes between sessions on the different questionnaires by means of testing for a main effect of time and interaction effects of time by order.

Pearson's correlation coefficients were calculated to investigate whether a relationship existed between SUDS and negative cognitions, and SUDS and presence.

RESULTS

Participant characteristics

In total, 35 subjects registered for participation, of which four subjects were rejected, because of a variety of reasons: eye problems ($n = 1$), a diagnosis of panic disorder with agoraphobia ($n = 1$), heart disease ($n = 1$), and unstable antidepressant medication ($n = 1$). Seven patients dropped out during therapy for various reasons. Four patients dropped out because VRET did not arouse anxiety (with an even distribution across conditions), and one dropped out because of simulation sickness during treatment. For ethical reasons, VRET was discontinued, and these five patients were offered treatment outside the experimental trial. Two subjects dropped out because of personal reasons, unrelated to VRET. Follow-up data are missing for three patients (two in the exposure-first condition, one in the cognition-first condition). Comparison between dropouts and the completers on background data and pre-treatment scores of the outcome measures revealed no significant differences.

Twenty-six patients remained in the study (14 males, 12 females). The average age of the patients was 50.5 years ($SD = 9.42$). No significant differences were found on sex distribution, age, BDI scores, and dependent variables at baseline between orders (VRET first or cognition first).

Effectiveness of treatment

A 2 (order) $\times$ 3 (time) repeated-measures analysis was run to evaluate order effects, treatment effectiveness, and differences in treatment effectiveness on the AQ-anxiety, AQ-avoidance, and ATHQ. Because of a violation of the sphericity assumption, adjusted degrees of freedom were used for analysis of within-subject data. It was found that there was no significant effect of order, $F(3, 22) = 0.17$, $p = 0.92$, and no interaction effect of order by time, $F(6, 94) = 1.84$, $p = 0.10$, indicating no order effect, and no difference in effectiveness of treatment between those who received VRET first, followed by VRET plus coping self-statements, and those who received VRET plus coping self-statements first, followed by VRET. A significant effect of time was found, indicating that treatment reduced anxiety, avoidance, and/or attitudes ($F(6, 94) = 8.36$, $p < 0.001$). Univariate analyses showed the same pattern of results. For means, SDs, and effect sizes on the AQ-anxiety, AQ avoidance, and ATHQ by order, see Table 1.

Post hoc analyses showed that the time effects were significant between pre- and intermediate test and between intermediate and post-test on all questionnaires (Table 2). This indicates that both treatment blocks reduced anxiety, avoidance, and negative attitudes towards heights.

A multivariate repeated-measures analysis (post- versus follow-up, dependent variables: AQ-anxiety, AQ-avoidance, and ATHQ) showed no significant effect of time, $F(3, 19) = 1.95$, $p = 0.16$, and no interaction effect of time by order, $F(3, 19) = 0.90$, $p = 0.46$. However, univariate analyses showed different results. A repeated-measures analysis showed a trend towards significance between post- and follow-up on the AQ-anxiety ($F(1, 21) = 3.37$, $p = 0.08$), and a second univariate analysis showed a signifi-

Table 1. Mean, Standard Deviation, and Cohen's *d* on the Pre-, Intermediate, and Post-Test of AQ-Anxiety, AQ-Avoidance, ATHQ, and Self-Efficacy

Dependent variable	*Order*	*Pre-test*	*Intermediate test*	*Post-test*	*d (pre–intermediate)*	*d (intermediate–post)*	*d (prepost)*
AQ-anxiety	VRET first	59.64 (15.86)	49.64 (17.15)	34.35 (11.57)	0.61	1.06	1.84
	Cogn first	59.83 (19.11)	48.17 (19.04)	39.00 (13.70)	0.61	0.56	1.27
AQ-avoidance	VRET first	14.36 (4.99)	12.21 (4.81)	8.21 (4.08)	0.44	0.90	1.36
	Cogn first	16.67 (6.96)	12.17 (6.79)	8.83 (5.83)	0.65	0.53	1.23
ATHQ	VRET first	47.42 (6.87)	39.93 (8.70)	30.50 (8.13)	0.96	1.12	2.26
	Cogn first	47.83 (8.94)	39.83 (9.35)	33.17 (10.94)	0.87	0.66	1.47
Self-efficacy	VRET first	173.85 (133.72)	273.71 (145.18)	317.21 (152.67)	0.72	0.30	1.00
	Cogn first	128.83 (120.60)	240.75 (139.90)	326.92 (130.51)	0.86	0.64	1.58

n (VRET first) = 14; *n* (cog first) = 12.

Cog first, VRET plus coping self-statements first; VRET, virtual reality exposure therapy; AQ, Acrophobia Questionnaire; ATHQ, Attitude Towards Heights Questionnaire.

Table 3. Mean and Standard Deviation (SD) of AQ-Anxiety, AQ-Avoidance, ATHQ, and Self-Efficacy at Post-Test and Follow-Up

Order	*AQ-anx post-test (SD)*	*AQ-anx follow-up (SD)*	*AQ-av post-test (SD)*	*AQ-av follow-up (SD)*	*ATHQ post-test (SD)*	*ATHQ follow-up (SD)*	*Self-eff post-test (SD)*	*Self-eff follow-up (SD)*
VRET first (n = 12)	33.25 (11.27)	37.67 (13.19)	7.92 (4.34)	8.83 (4.22)	30.75 (8.81)	35.08 (10.91)	338.42 (142.44)	283.67 (179.29)
Cog first (n = 11)	39.36 (14.31)	43.36 (24.28)	9.36 (5.80)	10.36 (8.00)	34.45 (10.47)	35.00 (11.29)	315.73 (130.71)	290.55 (166.38)

AQ-anx, AQ anxiety; AQ-av, AQ-avoidance; Self-eff, self-efficacy; Cog first, VRET plus coping self-statements first; AQ, Acrophobia Questionnaire; ATHQ, Attitude Towards Heights Questionnaire; VRET, virtual reality exposure therapy.

Table 2. Post Hoc Analyses of Time Effects

Measure	*Time*	*F*	*df*	p
AQ-anxiety	Pre-intermediate	34.96	1, 24	<0.001
	Intermediate post	21.72	1, 24	<0.001
AQ-avoidance	Pre-intermediate	49.33	1, 24	<0.001
	Intermediate-post	26.67	1, 24	<0.001
ATHQ	Pre-intermediate	20.52	1, 24	<0.001
	Intermediate-post	18.41	1, 24	<0.001

AQ, Acrophobia Questionnaire; ATHQ, Attitude Towards Heights Questionnaire.

cant time effect on the ATHQ ($F(1, 21) = 4.21$, $p = 0.05$). No significant time-effect was found on the AQ-avoidance ($F(1,21) = 2.65$, $p = 0.12$). Interaction effects (univariate) were not found. For means and SDs on the AQ-anxiety, AQ-avoidance and ATHQ at post-test and follow-up, see Table 3. These results indicate that gains made during treatment were not completely retained at follow-up.

Within sessions

A 2 (order) × 4 (time) repeated-measures analysis on the data of the SUDs showed no significant results. No effect of order ($F(1, 20) = 0.03$, $p = 0.86$), time ($F(3, 18) = 0.93$, $p = 0.45$), or an interaction effect of time by order ($F(3, 18) = 0.83$, $p = 0.50$) was found. These results indicate a stable pattern of SUD scores in both conditions. For means and *SDs* of SUDs by session, see Table 4.

A 2 (order) × 4 (time) repeated-measures analysis was run to examine the effect of treatment on presence. No significant effect of order ($F(1, 22) = 0.61$, $p = 0.44$) and no significant interaction effect of time by order were found ($F(3, 20) = 1.40$, $p = 0.27$). Moreover, no significant effect of time was found ($F(3, 20) = 0.19$, $p = 0.90$), indicating that patients felt the same amount of presence in each session regardless of order and treatment. For means and *SDs* on the IPQ, see Table 4.

A 2 (order) × 4 (time) repeated-measures analysis was run to investigate the effect of order and time and their interaction effect on the negative and positive cognition scale. No significant effect of order was found on the negative cognition scale, $F(1, 22) = 0.002$, $p = 0.96$. However, a significant effect of time was found on this scale, $F(3. 20) = 3.36$, $p = 0.04$, as well as a trend towards a significant interaction effect (time*order), $F(3, 20) = 2.68$, $p = 0.07$.

Post hoc analyses showed a trend towards a significant effect of time between session 1 and 2, $F(1, 22) = 4.03$, $p = 0.06$. No significant time effects were found between sessions 2 and 3, and sessions 3 and 4. No significant interaction effects were found between any pair of consecutive sessions. See Figure 1 for means on the negative cognition scale by order.

Because of a violation of the sphericity assumption, adjusted degrees of freedom and corrected tests were used for within-subject analyses on the positive cognition scale. On the positive cognition scale, no order effect was found, $F(1, 22) = 1.49$, $p = 0.24$, nor was a main effect of time, $F(3, 66) = 1.06$, $p = 0.37$. However, a marginally significant interaction effect between order and time was found, $F(3, 66) = 2.62$, $p = 0.057$. This indicates that the order in which treatment was received influenced the amount and/or intensity of positive cognitions reported. Post hoc analysis showed a significant in-

Table 4. Mean and Standard Deviation of the IPQ and SUDs by Session

Order	*Dependent variable*	*Session 1*	*Session 2*	*Session 3*	*Session 4*
VRET first ($n = 12$)	IPQ	56.33 (7.36)	58.17 (8.57)	53.75 (10.39)	56.08 (12.03)
	SUDs	19.00 (8.83)	17.67 (9.35)	17.17 (7.74)	17.67 (7.61)
Cog first ($n = 10$)	IPQ	52.53 (12.71)	51.75 (9.72)	53.42 (16.76)	55.00 (8.33)
	SUDs	19.10 (5.90)	14.90 (8.65)	20.00 (8.84)	19.50 (7.86)

IPQ, Igroup Presence Questionnaire; SUDs, Subjective Units of Discomfort; VRET, virtual reality exposure therapy; Cog first, VRET plus coping self-statements first.

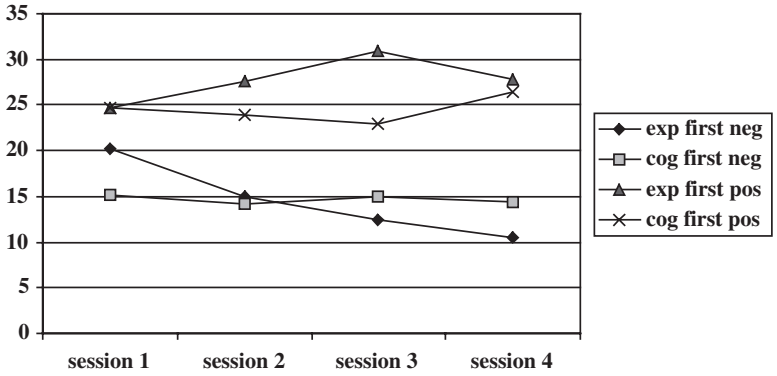

FIG. 1. Mean of the positive and negative cognition questionnaire after every session, n(VRET) = 12, n(cog) = 12.

teraction effect between sessions 2 and 3, $F(1.\ 22) = 4.44$, $p = 0.047$, indicating an increase in positive cognitions for patients receiving VRET plus coping self-statements (at session 3, condition VRET first) and a relative decrease in positive cognitions for patients receiving VRET without coping self-statements (at session 3, condition cognition first). Moreover, a significant interaction effect (time*order) was found between sessions 3 and 4, $F(1, 22) = 7.39$, $p = 0.01$, indicating a decrease of positive cognitions from session 3 to session 4 in the condition where patients received coping self-statements (VRET first condition), and an increase in positive cognitions in the condition where only VRET was given (cognition first condition). See Figure 1 for means on the positive cognition scale by order.

Correlation analysis showed that there was a relationship between SUDs and negative cognitions in every session, with one correlation being marginally significant (session 1, $r = 0.52$, $p = 0.02$; session 2, $r = 0.38$, $p = 0.06$; session 3, $r = 0.74$, $p < 0.001$; session 4, $r = 0.46$, $p = 0.03$). No significant correlation was found between SUD scores and IPQ scores in any session.

DISCUSSION

This is the first study in which the effectiveness of VRET and VRET plus coping self-statements was directly compared. In this cognitive procedure, only negative cognitions were identified and more neutral self-statements formulated and used during VRET. The findings indicate that the addition of coping self-statements did not influence the effectiveness of treatment. Both treatments were found effective regardless of order. Treatment effects (pretest compared to post-test on three main outcome measures) were substantial according to Cohen's d (AQ-anxiety, $d = 1.27$–1.84, AQ-avoidance $d = 1.23$–1.36, and ATHQ, $d = 1.47$–2.26). The effect sizes found in this study on anxiety were comparable or even slightly greater to treatment effect sizes found in earlier studies on VRET of acrophobia. Emmelkamp et al.[14] found an effect size of 0.99 after two sessions, Emmelkamp et al.[16] found an effect size of 1.28 after three sessions, and Krijn et al.[18] found an effect size of 1.31 after four sessions of VRET. However, it was found that progress made during treatment was not completely retained at 6-month follow-up, but difference between pre-test scores and follow-up scores were still substantial.

From the within-session data, it can be concluded that no relationship was found between IPQ scores and SUDS. The addition of cognitive techniques during VRET did not influence the amount of presence felt in the VEs. Moreover, negative cognitions showed a small decrease during sessions regardless of techniques used (VRET or VRET plus coping self-statements). It must be said that the scores on the negative cognition questionnaire after session 1 were on average already quite low, indicating that (further) treatment could not result in a substantial decrease of negative cognitions on this questionnaire. Unfortunately, no indication of negative cognitions was available before treatment started, so no information can be given on the effect of session 1. However, positive cognitions, as measured with an acrophobia cognition questionnaire, were more frequently reported during VRET plus coping self-statements at session 3 than VRET alone. It could be that a first session of coping self-statements would increase the positive cognitions temporarily. However, no firm conclusions can be drawn since no cognition questionnaire was given before session 1. Moreover, the further rather stable pattern of positive cognitions could be due to the idiosyncratic nature of the coping statements formulated in therapy and the more general positive cognitions phrased in the acrophobia cognition questionnaire.

Other research on the effectiveness of exposure plus coping self-statements for specific phobias showed a decrease in negative cognitions as well, albeit greater than in our study. Maltby et al.[22] found that negative cognitions with regards to fear of flying decreased after VRET plus anxiety management training (including the use of coping self-statements). Emmelkamp and Felten[15] showed that acrophobic subjects in an exposure plus coping self-statements condition had more positive cognitions and less negative cognitions compared to subject in an *in vivo* exposure-only condition (randomized between-subjects trial). However, it must be emphasized that, in this study,[15] the procedure used to register cognitions was thought listing, which differed from our study. It is known that production strategies often generate different results than endorsement measures in cognitive assessment,[7] which might explain the differences found (with regards to positive cognitions). In conclusion, negative cognitions seem to decrease during exposure *in vivo* as well as during VRET, regardless of the addition of cognitive techniques and more specifically coping self-statements. Unfortunately, no conclusions can be drawn on the process of positive cognitions during and after therapy because the only studies in patients with specific phobia reporting on positive cognitions are the present study and the study by Emmelkamp and Felten,[15] using different measures with mixed results.

This study has some limitations that should be mentioned. First, a waiting list control condition was not present, as a result, of which an effect of time or chance cannot be ruled out. However, it must be noted that, in another trial with acrophobics of the same research group using the same virtual worlds,[18] a waiting list control groups showed a stable pattern of anxious complaints.

Future research would profit from the addition of a behavioral avoidance test to analyze the effect of treatment on real anxiety-provoking situations and generalization to the real world. It should be noted, however, that in other studies of our research group, self-reported fear reduction generalized to behavioral avoidance measures.[16,18] Future research on process variables of VRET could also measure the use and intensity of the more idiosyncratic self-statements formulated in treatment. This could give a more detailed insight in the cognitive process of subjects during VRET, and VRET plus coping self-statements. Moreover, VEs and VRET could be used to investigate cognitive biases often found in phobic patients[11,21] and possible changes in these biases during and after treatment. In this study, coping self-statements were taught and used in two sessions, which is a relatively short period of time. Future research could expand the number of treatment sessions spent on VRET plus coping self-statements, and could investigate whether this would affect treatment effectiveness. Moreover, other cognitive techniques than coping self-statements could be used, such as the Socratic dialogue and other cognitive restructuring techniques.

Also the results of this project should be replicated using a different research design, where patients are either assigned to either VRET or VRET plus coping self-statements. This would bolster the conclusions.

Finally, despite the necessary caution in interpreting the results of the present study, the results do indicate that coping self-statements were not important as treatment component for acrophobia when used in addition to VRET. Future studies should help to clarify further the process of cognitive behavior treatment of acrophobia by means of virtual reality.

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