Dysfunctional beliefs in the process of change of cognitive treatment in obsessive-compulsive checkers

Abstract

Cognitive behaviour therapy (CBT) is considered to be effective in the reduction of obsessive-compulsive symptoms. However, questions remain as to how CBT works. Cognitive-behavioural models postulate that negative appraisals of intrusive thoughts and dysfunctional beliefs that give rise to them underlie the development and maintenance of OCD. The current study aims to study this hypothesis by investigating the processes of change over the course of cognitive treatment for OCD. Furthermore, a new theoretical approach and method for studying processes of change is presented. Participants were seven patients suffering from OCD with predominantly checking symptoms. Process variables (beliefs, anxiety, and compulsions) were measured using idiosyncratic diaries, and were analysed on an intra- and inter-individual level using dynamic systems methods. Results showed significant decreases in credibility of dysfunctional beliefs in six out of seven participants, which is in line with the cognitive-behavioural model. Associations between process variables (dysfunctional belief, anxiety, and compulsion) were in general medium to high. However, the actual patterns of change showed important intra- and interpersonal differences. Results indicate that different paths can lead to clinical recovery, and it is concluded that process studies which focus on individual trajectories of change can contribute to our understanding of OCD and its treatment. Furthermore, dynamic systems methods provide insight into intra-individual processes and shed a new light on variability.
1. Introduction

Wide-spread evidence has established the beneficial effects of cognitive behaviour therapy (CBT) in the reduction of obsessive-compulsive symptomatology: Exposure with response prevention (ERP) is currently considered the gold standard in treating obsessive-compulsive disorder (OCD) (Foa, Franklin & Kozak, 1998), and evidence for the efficacy of cognitive treatment (CT) is emerging as well (Cottraux, Note, Yao, Lafont, Note, Mollard et al., 2001; Freeston, Ladouceur, Gagnon, Thibodeau, Rhéaume, Letarte et al., 1997; Van Oppen, De Haan, Van Balkom, Spinhoven, Hoogduin & Van Dyck, 1995a; Whittal, Thordarson & McLean, 2005). However, questions remain as to how CBT works. According to Marks (2002, p 200) ‘therapy is coming of age regarding efficacy for anxiety and depression, but is only a toddler regarding the scientific principles to explain its effects’. Despite the great contribution of cognitive-behavioural models in the understanding and treatment of OCD, the formal study of mechanisms and processes of change is still in its infancy. Cognitive-behavioural models of OCD postulate that negative appraisals of intrusive thoughts underlie the development and maintenance of obsessions and compulsions (Clark & Purdon, 1993; Rachman, 1997, 1998, 2002; Salkovskis 1985, 1989; Wells, 2000). Hence, modification of automatic thoughts about the meaning of intrusions and the beliefs that give rise to them, should lead to a decrease in OCD symptoms. Six belief domains are currently considered to be relevant for OCD; over-importance of thoughts, importance of controlling one’s thoughts, perfectionism, inflated responsibility, overestimation of threat, and intolerance of uncertainty (Obsessive Compulsive Cognitions Working Group (OCCWG), 1997).

Several outcome studies suggested a relationship between successful treatment (ERP as well as CT) and significant changes in obsessional beliefs and intrusions (Bouvard, 2002; Emmelkamp, Van Oppen & Van Balkom, 2002). However, for both treatments it cannot be established whether changes in dysfunctional beliefs are mediators of symptomatic outcome, or whether they co-vary with or maybe follow changes in obsessions and compulsions, since only pre and post measurements were carried out. Process research, which focuses on patterns of change of overt and covert client behaviour, could shed more light on how treatment works, and hence could ultimately provide a more critical test of the cognitive-behavioural model of OCD (i.e., determine whether decreases in dysfunctional beliefs mediate clinical outcome) (Tolin, Woods & Abramowitz, 2003).

Besides enabling the study of mediators and moderators of change, process studies provide information about the shape of change over the course of therapy (cf. Laurenceau, Hayes & Feldman, 2007), which can have both important theoretical- as well as clinical implications. For instance, depressed patients showed worsening and more variability during an exposure phase of the provided treatment, which also predicted a better treatment effect (Hayes, Feldman, Beevers, Laurenceau & Cardaciotto, 2007). It was hypothesized that the sudden worsening and increased variability were due to integrating new knowledge and experiences,
which could lead to more ‘chaos’ in the beginning. Besides being an interesting theoretical finding, these results are also clinically important. If a therapist knows that depressive symptoms can worsen during an exposure phase, this might influence the decision as for when to start with this part of treatment (i.e., when a patient has the resources to deal with this destabilization) (Hayes et al., 2007). Therefore, more knowledge about the processes and mechanisms of change may help to optimize treatment methods and their effects, and may enhance the understanding of a particular disorder (Whisman, 1993).

Rhéaume and Ladouceur (2000) investigated processes of change in both ERP \((n=3)\), and CT \((n=3)\) for OC checkers. Data were analysed using Multivariate Time Series Analysis (V-ARMA), and results showed decreases in beliefs in both treatments. These decreases in beliefs sometimes preceded decreases in checking behaviour during treatment, but sometimes also followed behavioural changes. This was found in most patients, suggesting that, contrary to the theoretical expectations, the relationship between changes in beliefs and changes in checking behaviour might be bi-directional. Recently, Storchheim and O’Mahony (2006) studied the functional relationship between OCD relevant general belief domains (as identified by the OCCWG, 1997), obsessions, and compulsions \((n=6)\). The treatment consisted of two phases; first patients received five sessions of ERP followed by seven sessions of ERP + CT. Visual inspection showed that changes in compulsive behaviours, obsessions and OC beliefs occurred primarily in tandem over treatment phases, suggesting functional links between these elements. Limitations of this study are that results were based on visual inspection only, and that during the second phase of treatment a new treatment module (CT) was added to the provided ERP treatment, therefore the question remains whether changes in the second phase were brought about by the newly introduced CT module or were elicited by the ongoing ERP (see for a review of process studies in OCD and methodological considerations for studying processes of change Polman, Bouman, Van Hout, De Jong & Den Boer, 2010).

One complicating factor in studying processes of change is data-analysis. Since many data-points are involved and the focus is on individual trajectories of change, techniques are required which can provide meaning to intra- and inter-individual differences. ANOVA-based analyses do not match with this type of research question, since individual differences are attributed to sampling or measurement error, resulting in a fixed-effects model that assumes that everyone in that group had the same treatment effect. Piecewise linear growth modelling (a subtype of the hierarchical linear model, which can accommodate fixed effects (i.e., group effects) and random effects, such as session-specific or subject-specific effects (see Bryk & Raudenbush, 1992) is one of the leading techniques to analyse process data (cf. Laurenceau, et al., 2007). However, a disadvantage of this technique is that it assumes unbounded increases or decreases in symptoms (increases or decreases to infinity), whereas in clinical practice symptom patterns might be more dynamic, e.g., oscillations around an equilibrium, or sudden shifts
Dynamic systems methods represent an alternative approach to modelling these types of non-linear and discontinuous trajectories. This technique is based on the dynamic systems theory (e.g., Thelen & Smith, 1994; Van Geert, 1994; Van Geert & Steenbeek, 2005), which emphasizes the relevance of variability which is considered to bear important information about the nature of developmental processes. According to this theory, change is associated with destabilization of the system (i.e., the patient); old patterns become less viable, and new patterns are emerging, which causes fluctuations. Variability is considered to decrease when the system settles into a new dynamic state (Thelen & Smith, 1994; Van Geert, 1994; Van Geert & Steenbeek, 2005).

The present study was designed to further the investigation of change processes in CBT for OCD, by exploring the feasibility of dynamic systems methods in a clinical context. In a case series of seven OCD checkers, individual trajectories of change were investigated over the course of cognitive treatment. Since OCD is a heterogeneous disorder we focussed on a specific subtype (i.e., compulsive checking) to minimize between-subject variability. Furthermore, we implemented one type of treatment to prevent a possible carry-over effect (cf. Storchheim & O’Mahoney, 2006). Based on the cognitive-behavioural model the following hypotheses were investigated: a. Credibility of OC beliefs decreases over the course of effective treatment as shown by Rhéaume & Ladouceur (2000), and Storchheim & O’Mahony (2006), and b. Changes in credibility of OC beliefs are positively correlated with changes in anxiety/distress, and compulsive behaviour. Furthermore, in line with process studies in depression (e.g., Hayes, et al., 2007; Tang & DeRubeis, 1999), patterns of change were explored.

2. Method

2.1 Participants and procedure
Participants were seven consecutively referred patients suffering from OCD, presenting predominantly checking symptoms. Participants were referred to the outpatient facility of the department of Clinical Psychology by their general practitioner (n=1), Mental Health Institutions (n=4), or were self-referred (n=2). Inclusion criteria were: (1) a primary diagnosis of OCD according to the DSM-IV-TR criteria (American Psychiatric Association, 2000), which was screened by the first author using a Dutch version of the MINI-plus (Sheehan, Lecrubier, Harnett-Sheehan, Janavs, Weiller, Bonara, et al., 1997), with checking as the main symptom; (2) age between 18-65 years; (3) duration of OCD at least six months. Exclusion criteria were: (1) risk of psychosis or suicide; (2) substance abuse; (3) CBT for OCD in the past five years; (4) concurrent psychological treatment for OCD; (5) symptom contingent or varying antidepressants use, or use of other psychotropic drugs (time
contingent (i.e., daily) antidepressants use with a stable dose was allowed); (5) mere presence of obsessions.

In Table 1 biographical and clinical characteristics of the participants are described. Three participants received anti-depressant medication for OCD, which they started using at least two months before participation in this study. The medication was taken on a time contingent basis and the dosage was stable, which was assessed daily in a diary and verified by the therapist weekly. All participants completed treatment, and participants 3 and 6 received five additional sessions after follow up.

2.2 Design
A multiple baseline across subjects design was used. With this type of design, the effect of the intervention can be demonstrated by showing that behavioural change accompanies introduction of the intervention at different points in time (Kazdin, 2003). Baseline lengths were 14, 21, 27, 28, 35, 42, and 44 days, to which participants were randomly assigned irrespective of symptom severity. This design was combined with questionnaires and a semi-structured interview at pre-tests (before and after baseline), at mid-test (preceding session 8), at post-test, and at 1-month follow-up. If necessary, participants received additional treatment after the follow-up.

2.3 Treatment
The cognitive treatment consisted of 15 weekly sessions of one hour plus 1 follow up session which took place four weeks after session 15. The treatment was based on the general approach of cognitive therapy for OCD proposed by Salkovskis (1985, 1989), which was further developed by Van Oppen and Arntz (1994), and Rachman (1997, 1998). In the first treatment session, participants were socialized to the cognitive-behavioural model of OCD, emphasizing the role of dysfunctional beliefs. Furthermore, written information on the treatment rationale and procedure were provided. The following sessions focused on identification of appraisals and beliefs, and subsequently also on challenging and modification of beliefs. Mainly verbal challenging techniques were applied, using Socratic questioning. Examples of frequently used techniques are: pie-chart technique, estimation of catastrophe, two column technique, and multidimensional evaluation. Additionally, behavioural experiments were used to test the empirical basis of the dysfunctional assumptions. For instance, one participant was afraid that she could turn on the stove accidentally, by lightly touching the stove or by bumping into it with her bag. To test whether this was possible, she touched the stove in different ways, the most extreme way being bumping into the stove while wearing a backpack. None of the ways led to turning on the stove, and she concluded that it was not possible to turn on the stove this way. The behavioural experiments differed from ERP since there
was no instruction to remain in the situation until anxiety decreased, and there were no response prevention instructions either. Another type of behavioural experiment conducted with different participants was asking an expert on a certain topic for information to check whether certain beliefs were valid. All experiments started with the formulation of an assumption or belief, which was then challenged by an experiment, and finally evaluated and modified. No explicit exposure with response prevention instructions were provided during treatment.

Apart from the weekly sessions with the therapist, patients were asked to do homework assignments, in which they had to write down a difficult situation of that day, the thoughts they had at that time, level of anxiety or distress they experienced, and their behaviour. Subsequently, they were asked to use one of the techniques introduced in the treatment sessions to challenge, evaluate and modify this thought. Progress and problems with last week’s homework assignments were discussed at the start of each treatment session.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age</th>
<th>Occupation</th>
<th>Medication</th>
<th>Duration of OCD</th>
<th>Prior treatment &gt; 5 years ago</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>22</td>
<td>Student</td>
<td>20 mg paroxetine</td>
<td>10 months</td>
<td>12 sessions of supportive psychotherapy</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>23</td>
<td>Medical receptionist</td>
<td>None</td>
<td>1.5 year</td>
<td>10 sessions in which the past week was discussed + keeping a diary</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>44</td>
<td>Medical technical and administrative employee</td>
<td>75 mg venlafaxine</td>
<td>25 years</td>
<td>Relaxation exercises + conversations about the development of the OCD</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>21</td>
<td>Student</td>
<td>None</td>
<td>4 years</td>
<td>9 sessions of behaviour therapy</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>23</td>
<td>Student</td>
<td>None</td>
<td>5 years</td>
<td>Psychological treatment for depressive symptoms</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>23</td>
<td>Student</td>
<td>None</td>
<td>3 years</td>
<td>8 sessions of ERP</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>24</td>
<td>Student</td>
<td>30 mg paroxetine</td>
<td>4 years</td>
<td>+/- 4 sessions of CBT for hypochondriac symptoms</td>
</tr>
</tbody>
</table>
2.4 Therapists
Therapists were graduate students in clinical psychology (7F, mean age 22 years) who had received an intensive training in the specific aspects of CT for OCD. The training consisted of four 3-hour periods in four weeks, during which the cognitive-behavioural model of OCD was discussed, and treatment situations were practised. Homework assignments included studying literature and practical exercises. To enhance treatment integrity a treatment manual (55 pages) was used with detailed information on OCD, cognitive treatment for OCD, and session-by-session instructions. Furthermore, therapists had weekly supervision with the first author, in which audiotapes of the sessions were used to enhance treatment integrity. Participants were randomly assigned to one of the therapists.

2.5 Measures
2.5.1 Outcome measures
The Yale Brown Obsessive Compulsive Scale (Y-BOCS) (Goodman, Price, Rasmussen, Mazure, Fleischmann, Hill et al., 1989a; Goodman, Price, Rasmussen, Mazure, Delgado, Heninger et al., 1989b) is a clinician-rated semi-structured interview consisting of 10 items measuring severity of obsessions (5 items) and compulsions (5 items). Investigation of the Dutch version revealed excellent inter-rater agreement and internal consistency, and good divergent validity (Arrindell, Vlaming, Eisenhardt, Van Berkum & Kwee, 2002). This instrument was administered by the first author.

The Padua Inventory-Revised (PI-R) (Van Oppen, Hoekstra & Emmelkamp, 1995b, Sanavio, 1988) is a self-report questionnaire consisting of five subscales; impulses, washing, checking, rumination, and precision. Psychometric properties of the Dutch version are satisfactory (Van Oppen et al., 1995b).

To measure OCD relevant beliefs the Obsessive Beliefs Questionnaire (OBQ) (OCCWG, 1997, 2003, 2005; Dutch version Emmelkamp, Van Oppen & Wieringa, 1998) was administered. Psychometric validation of the OBQ showed good internal consistency and criterion-related validity in clinical and non-clinical samples (OCCWG, 2003, 2005)

2.5.1 Process measure: diary
To measure processes of change, participants kept an idiosyncratic structured diary on a daily basis, during baseline, treatment, and one month after treatment. A tailor-made diary was constructed in consultation with the participant during a specific case formulation session, which took place before the start of the actual treatment. During this case formulation session idiosyncratic obsessions, compulsions and dysfunctional beliefs were formulated. This way, each participant kept a diary with symptoms that were relevant for her which were stable over treatment, enabling comparisons of intra- and inter-personal changes over time. Based on the cognitive-behavioural model of OCD, anxiety/distress, credibility of idiosyncratic
OC beliefs, and time spent on idiosyncratic compulsions were assessed. All process variables were scored on a scale from 0 to 100, 0 meaning not relevant/credible/low today, 100 meaning very credible/relevant/high today. This 0-100 scale was chosen for compulsions as well, since some compulsions take only little time, but are conducted frequently, whereas others are conducted less frequently but for a longer period of time.

Participants were asked to fill out their diaries once a day, preferably in the evening. The diaries were little booklets, consisting of an instruction sheet and seven actual diary sheets to fill out (one page per day). Each participant had several data-entries with respect to idiosyncratic beliefs and compulsions. Anxiety/distress had one data-entry referring to the average level of anxiety/distress for that day. Altogether, this provided an impression of severity of OCD complaints, subdivided into beliefs, anxiety/distress, and compulsions. All participants had one idiosyncratic belief concerning responsibility, and had checking as main compulsion, therefore, these beliefs and compulsions were used in the analyses.

2.6 Statistical analysis
2.6.0 Overview
Globally speaking, the following steps were conducted in the analyses: Firstly, questionnaire data were analysed per participant in order to test whether the provided treatment was efficacious. The second step consisted of the analyses of the diary data. Analyses of the baselines were conducted to test whether participants’ symptoms changed during this period. Subsequently, changes on process parameters during treatment were tested, which was followed by testing whether these changes correlated as would be predicted by cognitive-behavioural models. Finally, patterns of change on process parameters were studied.

2.6.1 Outcome
To test whether a significant decrease in OC symptoms occurred, reliable change (RC) indices were computed for the sum-scores of the Y-BOCS, PI-R, and the OBQ between pre- and post treatment. The difference between the pre- and post-assessment of the Y-BOCS was divided by its standard error of difference. The same was done for the PI-R and the OBQ, respectively. By dividing the amount of change by the standard error of difference between the two test scores, this index provides information on whether the change reflects more than the fluctuations of an imprecise measurement. RC>1.96 would be unlikely to occur (p<.05) without actual change (Jacobson & Truax, 1991).

Since a statistically significant treatment effect does not necessarily imply a clinically meaningful improvement, clinical significance (the extent to which therapy moves someone outside the range of the dysfunctional population or within the range of the functional population) was established for the OCD symptom measures (Jacobson & Truax, 1991). Based on Steketee, Frost, and Bogart (1996), the
cut-off point for the Y-BOCS was deemed 14. The cut-off point for clinically significant change on the PI-R was 53 (Van Oppen, Emmelkamp, Van Balkom & Van Dyck, 1995c).

2.6.2 Process
2.6.2.1 Baselines
Before testing our hypotheses concerning the cognitive-behavioural model of OCD, we first established whether the multiple baselines were stable across subjects. According to Kazdin (2003) baselines are considered to be stable if the data do not show a general trend (i.e., increase/decrease) and show only little variability. To test whether the multiple baselines were stable across subjects, Monte Carlo Simulation was used on the diary data. These techniques test significance through simulating the null hypothesis (=fluctuations are based on chance) by resampling the observed data by drawing with replacement from the original data a great many times (in our study, the standard procedure is to resample 1000 times) (for a discussion of random permutation and random sampling techniques, in particular in small and time-serial samples, see Good, 1999, 2004; Manly, 1997; Toddman & Dugard, 2001). Monte Carlo procedures are extremely flexible and parameter free, which is an important feature when analysing time serial data, since most standard statistical methods require independence of measurements/datapoints.

Since we expected baselines to be stable, fluctuations during baselines should not be distinguishable from fluctuations that are merely due to chance, i.e., the fluctuations lack any form of systematic trend. Hence, the hypothesis to be tested is that the observed scores are not distinguishable from scores based on random fluctuations along a constant mean. A convenient way to express that the mean is not changing over time, is by calculating the slope of the series, and to determine whether the slope lies within a confidence interval of slopes based on random fluctuations around a fixed mean. This confidence interval and associated p-values will be calculated by means of the Monte Carlo procedure.

For each resampled set (with a total of a thousand sets), the value of a statistic of interest is calculated (in this case slope during baseline). These values are then used to calculate confidence intervals (e.g., the upper and lower values of the slopes within which 90% of the simulated cases are confined, which corresponds with a two-sided p-value of 5%). The confidence intervals are then compared to the observed scores. Since baselines are supposed to be stable, the slopes of the observed scores during baseline should not be significant, meaning that they cannot be distinguished from random change. Since time series are characterized by serial dependency in the data, also known as autocorrelation (i.e., the score on a particular day on a certain variable will be influenced by the scores of previous days), random sampling was carried out for randomly selected units of four consecutive datapoints. By doing so, the random sampling sufficiently conserves the autocorrelation and thus guarantees an optimally reliable result of the test procedure.
2.6.2.2 Changes of process parameters during treatment

Changes in process parameters over the course of treatment were tested in two ways: First the means during treatment and follow up were compared. Subsequently, the slopes during treatment were analysed to test whether there was a decreasing trend over the entire treatment period. A linear regression model with time as independent variable was calculated for the diary data. Since a decreasing trend is expected during treatment, slopes are expected to be negative. The slope should fall beyond the confidence interval calculated by means of a Monte Carlo method, for slopes resulting from the null hypothesis model (all differences between scores are random fluctuations around a fixed mean based on chance). The differences in dysfunctional beliefs, anxiety, and compulsions between treatment and follow up period, as well as the slopes during treatment were used for calculations.

2.6.2.3 Associations between process parameters and index of support

Based on the cognitive-behavioural model of OCD, it was hypothesized that changes in credibility of OC related beliefs should positively correlate with changes in distress and compulsive behaviour. It is important to know whether this correlation is a stable property across the whole time series. A statistically significant correlation over the whole time period of observations does not necessarily imply that the correlation holds for any sub-period of reasonable duration. It is possible, for instance, that a period of very high correlation is followed by periods with no or opposite correlations, nevertheless resulting in a significant overall correlation. If the theory predicts a particular correlation, the correlation should hold for any time window of sufficient length (“sufficient” is defined as any length, i.e., number of consecutive observations, required for calculating reliable p-values for the correlations found). The expected stability of the relationship between process variables is examined by computing so-called moving correlations per participant between dysfunctional belief and anxiety, dysfunctional belief and compulsion, and anxiety and compulsion. Moving correlations were computed by correlating the raw data of the two variables at hand over a window of 15 observations. We preferred a window of 15 data points as a reasonable compromise between a series length sufficient for obtaining meaningful correlations, and a series length short enough to capture fluctuations over time. To test whether associations were

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1 The choice of a window length is based on a compromise between requirements of sensitivity and requirements of reliability: sensitivity means that the window should be short enough to capture the fluctuations of the variable of interest over time; reliability means that the window should be long enough to allow for a reliable representation of the variable in question. The problem of window length is one of finding an optimum, and is to a certain extent always arbitrary, with small differences in the chosen window length (a bit more or a bit less) not meaningfully affecting the results of the analysis. The compromise between sensitivity and reliability depends on the nature of the data and of the variable of interest (it is longer for a window needed for a moving correlation than for a window needed for a moving maximum value for instance).
significantly positive, we calculated the 95% boundary of the correlations over the 15-observations windows based on the null hypothesis model (“no association between variables”). Figure 2 shows this boundary for 2 participants. All observed correlations over 15-observation-windows above this boundary can be evaluated as reliable positive correlations (only 5% chance that these correlations are accidental), which is what the theory predicts. Hence the total surface of correlations (let us call it a) above the 95% boundary (the vertically hatched regions in figure 2) can be conceived of as a measure of the degree of support for the hypothesis. However, correlations often lie under this 95% boundary, which is in contrast with what the theory predicts. Hence, the total surface of such correlations (the horizontally hatched regions in figure 2, which we shall call b), provides an indication of the degree to which the data diverge from the predictions of the theory. The proportion of support (a) over divergence from the hypothesis (b), i.e., the proportion of vertically over horizontally hatched regions, provides a numerical indication of the degree of support for the theory by the data, i.e., an indicator of theory fit of the data. In order to avoid eventual division by 0, we suggest the proportion a/(a+b) as a numerical indicator of support for the hypothesis, with 1 equal to complete support (no divergence) and 0 equal to complete lack of support (only divergence). We suggest to call this proportion the index of support, or is. The index of support provides a direct measure of hypothesis fit and explicitly accounts for the amount of fluctuation in the associations among variables.

2.6.2.4 Patterns of change of idiosyncratic dysfunctional beliefs
In order to visualize and describe intra-individual variability in individual time-serial data of repeated observations we used the min-max graph method introduced by Van Geert and Van Dijk (2002). This graph consists of three lines; the moving average, the moving minimum and the moving maximum. The moving minimum and maximum around the general trend (moving average) provide an indication of the bandwidth of observed scores. The moving average was obtained by taking the average of 9 successive observations. First the average of observation 1 to 9 is calculated, then the window of 9 is moved to observations 2 to 10, then 3 to 11, and so forth. The moving minima/maxima were computed by taking the two lowest/highest scores in a window of nine observations, and dividing them by two. Then the same procedure was carried out for observations 2 to 10, 3 to 11, and so on similar to the moving averages. After this procedure, the data still shows a lot of fluctuations which complicates visual inspection. To further refine data presentation, a sophisticated smoothing technique called Loess Smoothing (Härdle, 1991; Simonoff, 1996) was used. With this technique actual increases and decreases in the data can be followed as accurately as one wishes, depending on the size of the window that is selected. In this study, we used a window of 55 observations, which is an arbitrary choice, based on the optimal way to present general trends and
local fluctuations\(^2\) (see also footnote 1). Visual inspection of the min-max graph provides information on the pattern of change on an intra-individual level and is especially useful for visual inspection of changes in the bandwidth of the variability, i.e., changes in the degree of fluctuation over time.

2.6.3. Outcome and process
In addition to data analysis on an intra-individual process level, we were also interested in the relationship between process and outcome. Based upon the cognitive-behavioural model one would expect that decreases in beliefs take place, and that changes in beliefs, anxiety, and compulsions are correlated. Therefore, it would be interesting to compare the processes of change of two participants who improved considerably (both statistically and clinically), and examine whether both of them showed improvement according to the expectations based on the cognitive-behavioural model. If the processes of change are different this would be an indication that change can take place along different paths. In order to examine this relationship we will pay extra attention to comparing the process results of the two most improved participants, as established by the Y-BOCS.

3. Results

3.1 Outcome
In order to establish treatment effect, reliable change indices were computed. As can be seen in Table 2, six out of seven participants improved significantly on the Y-BOCS, and four of them also showed a clinically relevant improvement. Only one participant improved significantly on the PI-R. Interestingly, this is the same participant who did not improve significantly on the Y-BOCS. On the OBQ, three participants improved significantly, and one participant showed a significant increase.

As mentioned above, besides presenting the results of all participants, we will pay special attention to the two most improved participants as established by the Y-BOCS, which will be participants 2 and 5 (see Table 2). Both of them showed clinically significant improvements on the Y-BOCS, as well as significant decreases on the OBQ.

\(^2\) The reliability of a smoothing technique is represented by the symmetry of the residuals. More specifically, a smoothed representation of a data set should have about an equal number of observations below and above the smooth line.
3.2 Process

3.2.1 Baselines
To establish whether the multiple baselines were stable across subjects, we tested the slopes for the three process variables (anxiety, dysfunctional belief, compulsion) within each participant using Monte Carlo Simulations. The slopes per participant are presented in Table 3. No significant increases or decreases on any of the process variables were found in participants 1, 2, 4, and 7. Only participant 3 showed a significant decrease in anxiety during baseline. Participants 5 and 6 showed significant increases in idiosyncratic dysfunctional beliefs, and participant 6 also showed a significant increase in anxiety. Overall, we can conclude that the majority of baselines were fairly stable, i.e., trends in the baselines cannot be distinguished from those found through random fluctuations. However, some participants showed considerable fluctuations, indicating trends in clinically relevant variables that were either spontaneous, or possibly caused by the client’s anticipation of treatment. However, these significant changes only concerned a significant decrease in anxiety in one participant, whereas the other two worsened during baseline, indicating that in general no considerable improvements took place during that period. In Figure 1, the raw and smoothed data of participants 2 and 5 (most improved participants as measured by the Y-BOCS) during their baseline periods are plotted. The smoothed lines indicate a slight worsening of participant 2, and a low stationary level in participant 5.

3.2.2 Changes in process parameters over the course of treatment
Changes in process parameters over the course of treatment were tested in two ways using Monte Carlo techniques. First the means during treatment and follow up were compared. Subsequently, the slopes during treatment were analysed to

Table 2. Individual pre- and post-treatment scores and reliable change indices on outcome variables

<table>
<thead>
<tr>
<th>Participant</th>
<th>Y-BOCS</th>
<th>PI-R</th>
<th>OBQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>RC</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>14</td>
<td>-1.31</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>4</td>
<td>-3.40**</td>
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<td>3</td>
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<td>6</td>
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</tr>
<tr>
<td>7</td>
<td>25</td>
<td>13</td>
<td>-3.14**</td>
</tr>
</tbody>
</table>

Note: Y-BOCS= Yale Brown Obsessive Compulsive Scale; PI-R= Padua Inventory-Revised; OBQ= Obsessive Beliefs Questionnaire; RC= Reliable Change Index; *= p<.05; **= p<.05 & clinical significant; Pre=before starting treatment; Post= after treatment.
test whether there was a decreasing trend over the entire treatment period. When comparing means during treatment and follow-up, results (see Table 3) showed significant decreases in credibility of dysfunctional beliefs in all participants except

![participant 2 graph]

![participant 5 graph]

Figure 1. Baselines of participants 2 and 5
Table 3. Changes in process parameters during baseline, treatment and follow-up, and treatment only

<table>
<thead>
<tr>
<th>Participant</th>
<th>Slope during baseline</th>
<th>Mean treatment-mean follow up</th>
<th>Slope during treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Belief</td>
<td>Anxiety</td>
<td>Compulsion</td>
</tr>
<tr>
<td>1</td>
<td>- .50</td>
<td>-.07</td>
<td>.20</td>
</tr>
<tr>
<td>2</td>
<td>-.32</td>
<td>.47</td>
<td>-.07</td>
</tr>
<tr>
<td>3</td>
<td>.80</td>
<td>-2.37*</td>
<td>-.146</td>
</tr>
<tr>
<td>4</td>
<td>-.14</td>
<td>-.40</td>
<td>.13</td>
</tr>
<tr>
<td>5</td>
<td>.90*</td>
<td>.06</td>
<td>.28</td>
</tr>
<tr>
<td>6</td>
<td>.85*</td>
<td>.64*</td>
<td>.19</td>
</tr>
<tr>
<td>7</td>
<td>-.14</td>
<td>-.08</td>
<td>-.38</td>
</tr>
</tbody>
</table>

*=p<.05; **=p<.01

Table 4. Support indices for the association between process variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Baseline</td>
<td>Treatment</td>
</tr>
<tr>
<td>1</td>
<td>.46</td>
<td>.10</td>
<td>.36</td>
</tr>
<tr>
<td>2</td>
<td>.29</td>
<td>.03</td>
<td>.65*</td>
</tr>
<tr>
<td>3</td>
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<td>4</td>
<td>.84**</td>
<td>.90**</td>
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<td>.70*</td>
<td>.90**</td>
</tr>
<tr>
<td>7</td>
<td>.23</td>
<td>.02</td>
<td>.21</td>
</tr>
</tbody>
</table>

* >.50; **>.80
Figure 2. Moving correlations between anxiety and beliefs of participants 2 and 5.

Reliable positive correlations are correlations above the 95% boundary (dotted line). Correlations below the 95% boundary are said to diverge from reliable positive correlations. The hatched surface above the 95% line is region a, below is region b. The index of support is the proportion a/(a+b).
Figure 3. Moving min-max graphs of all participants
DYSFUNCTIONAL BELIEFS AND PROCESSES OF CHANGE

Legend:
- minimum
- average
- maximum
- Y-BOCS value
for participant 4. The slopes during treatment showed declines in distorted dysfunctional beliefs in participants 3, 5, 6 and 7. Overall, we can conclude that a significant decrease in credibility of dysfunctional beliefs took place, and that in four out of seven participants there was a decreasing trend during treatment. When we compared the two most improved participants (based upon the Y-BOCS), both showed significant decreases in credibility of idiosyncratic dysfunctional beliefs. However, only participant 5 showed a general decreasing trend during treatment, whereas participant 2 showed an increase at the end of treatment.

According to the cognitive-behavioural model it was expected that anxiety and compulsions would decrease as well, which was tested using a similar approach. Results showed significant decreases in anxiety in all participants, when comparing the mean during intervention to the mean during follow up. In participants 1, 2, 3, 5 and 6, the slopes during treatment showed significant decreases in anxiety as well. Considering compulsions, participants 3, 5, 6, and 7 showed significant decreases when comparing treatment and follow up period. Participants 3, 5, and 6 also showed a significant decreasing trend in compulsions during treatment (see also Table 3).

3.2.3 Associations between process parameters
To test whether dysfunctional beliefs, anxiety and compulsions correlated over time, we computed moving correlations between dysfunctional belief and anxiety, dysfunctional belief and compulsion, and anxiety and compulsion for each individual participant. Overall moving correlations were positive. By means of a Monte Carlo procedure we tested whether the area above the 95% probability line, occupied by the observed data was significantly greater than the corresponding area occupied by the simulated data sets. This was found to be the case for all moving correlations and for all participants. However, this finding does not tell us whether in general process variables correlated over time. Therefore, we calculated the index of support for the entire time period, the baseline period, the intervention period, and the period one month after intervention (see section 2.6.2.3.). Percentages are presented in Table 4.

In general, mostly medium to high indices of support for the hypothesis of positive association between variables were found, implying that changes in beliefs, anxiety and compulsions were associated as predicted by the cognitive-behavioural model. If the whole time period is split up in baseline-, intervention- and follow up periods, results indicated less support, i.e., association between process parameters during baseline compared to intervention and follow up periods. Furthermore, individual differences become apparent: Participant 4 showed very high associations between all process variables during baseline, treatment and follow-up, whereas participant 5 showed hardly any significant associations.

Moreover, associations between changes in beliefs and compulsions seemed less associated than between belief and anxiety, and anxiety and compulsion. Interestingly, participant 1 generally showed medium associations during treat-
ment, and high associations during follow up. Figure 2 shows the results of the two participants who improved most on the Y-BOCS. Whereas participant 2 showed medium to high association during treatment and hardly any meaningful association during follow up, participant 5 hardly showed significant support indices during any time period, i.e., there is little support for the hypothesis that variables were positively associated in this participant’s case.

3.2.4 Patterns of change
To investigate patterns of change, both the moving min-max graph of a dysfunctional belief and the Y-BOCS scores at 5 time-points were plotted in one graph per participant. In Figure 3, the moving min-max graphs of all participants are presented. The differences in general trend and variability were remarkable. With regard to the general trend both differences in level and trend were striking. Overall, participants 2 and 4 rated their dysfunctional beliefs relatively low, although their max curves showed high(er) scores. Furthermore, score patterns of participants 2 and 4 seemed to keep fluctuating, whereas the means of participants 5, 6, and 7 showed gradual decreases. Concerning variability, the small bandwidths of participants 3 and 7 stood out. Furthermore, the increase in variability during treatment was remarkable in participant 2.

When comparing the two most improved participants (participants 2 and 5), considerable differences in patterns of change can be detected. First, the onset of change differed. A decrease in credibility of dysfunctional belief occurred at the end of treatment in participant 2, whereas participant 5 showed a gradual decrease during the entire treatment period. Second, the patterns of change were quite distinct from each other; large amplitudes and increasing variability during treatment versus gradual change and a decreasing bandwidth at the end/second half of treatment. Results of these two participants showed that pathways to recovery can be characterized by a gradual decrease in symptoms and little variability, but also by discontinuous patterns and increases in variability. Finally, both participants showed drops in the max curves at the end of treatment, indicating decreases in positive extremes. This is clinically an important finding since it means that the more extreme and disturbing experiences of, for instance anxiety and compulsions, have decreased.

4. Discussion

4.1 Dysfunctional beliefs in the process of change
The theoretical aim of this study was to examine processes of change over the course of treatment by investigating individual patterns of change, and more specifically to study the role of dysfunctional beliefs in the process of change. Overall, the cognitive treatment seemed to be effective; six out of seven participants
improved significantly on the Y-BOCS and four of them also improved clinically significantly, which seems comparable to results of treatment outcome studies (cf. Öst, 2008). Based on the cognitive-behavioural model of OCD (Clark & Purdon, 1993; Rachman, 1997, 1998, 2002; Salkovskis, 1985, 1989; Wells, 2000), it was predicted that cognitive treatment would result in significant decreases of credibility of idiosyncratic dysfunctional beliefs. By and large the present findings are consistent with this prediction; a significant decrease in credibility of idiosyncratic OC dysfunctional beliefs was found in six out of seven participants. In four of these participants, decreases were established within the treatment phase, in the other two participants decreases commenced during treatment and continued during follow up.

Furthermore, the cognitive-behavioural model predicts that changes in credibility of OC-related beliefs would keep pace with changes in anxiety/distress and compulsive behaviour. In line with that prediction, mostly medium to high associations were found. This pattern of results is also in line with earlier findings, which indicated that changes in beliefs and behaviour tend to occur in tandem (Storchheim & O’Mahony, 2006). However, we found differences over time: sometimes changes in dysfunctional beliefs were opposite to changes in compulsions. Based on the dynamic systems theory, this might also indicate a temporal destabilization due to emotional processing. The most improved participant as measured by the Y-BOCS, did not show much association between changes in different process variables over the entire course of treatment. This seems to indicate that clinical improvement does not need to proceed strictly along the lines as predicted by the cognitive-behavioural model.

Finally, patterns of change were inspected, and it appeared that, in general, participants varied in degree of variability and amplitude. Furthermore, the moment change commenced and the pattern of change differed. Some patients seemed to improve gradually, whereas others showed more dynamic patterns of change, and in one case even seemed to get worse before improving. Dynamic patterns of change with sudden gains and or sudden worsening have been reported in depressed patients as well (Hayes, Feldman, Beevers, Laurenceau, Cardaciotto & Lewis-Smith, 2007; Tang & DeRubeis, 1999). The worsening could be a destabilizing period during a transition from old patterns of beliefs and behaviours to new ones. Another clinically interesting finding were the drops in the maximum scores at the end of treatment, since this would indicate that the more extreme experiences of anxiety and compulsions decreased or disappeared at the end of treatment.

Taken together, these intra- and inter-individual differences underline that CBT might not be a homogeneous and uniform process, as was also suggested by Tang and DeRubeis (1999). Different pathways can lead to clinical improvement, and an important research question would be to find out how to elicit change in different patients.
4.2 Dynamic Systems Modelling

From a methodological perspective, this study aimed to demonstrate and explore the possibilities of dynamic systems methods for process studies in a clinical context. Starting point of this approach is the statistical description and analysis of individual multi-variate time series, documenting the process of change by means of intensive measurements (e.g., daily measurements). Instead of assuming that everyone had the same treatment effect, and attributing individual differences to sampling or measurement error, dynamic systems modelling stresses the relevance of variability which is considered to bear important information about the nature of change processes, and tries to provide meaning to individual trajectories of change. Theoretically expected or predicted relationships can be calculated over time. It can thus be tested whether the relationships are indeed universal within individuals (i.e., they hold for any time window long enough to reliably show the predicted association) or whether such relationships themselves fluctuate over time (sometimes they hold, sometimes they do not). The finding that theoretically predicted relationships are themselves subject to (true) fluctuation has implications for the formulation of the theory.

Another advantage of starting from individual time series is that it allows to check the universality of a theoretically predicted relationship across individuals. That is, the theory might be true for some individuals, describing their individual trajectories quite reliably, but not or less so for others. If the latter is the case, the theory should be altered such that it can account for its idiosyncratic validity.

The techniques used in the present study also have a number of disadvantages, although most of them are due to the fact that the present approach is quite novel in the field of clinical psychology (and other sub-disciplines of psychology, for that matter). The researcher has to define his or her own statistical indicators of interest (in this case the slopes of the time series, moving correlations and an index of support) and carry out randomization tests, that are not standard components of the most current statistical packages (although possibilities for carrying out randomization tests are improving rapidly). However, a widely used spreadsheet program such as MS Excel, in addition to mathematically reliable randomization algorithms (such as the ones freely provided in the Excel Poptools add-in) suffice to do the randomization tests required for the current type of studies.

Another disadvantage of using techniques relying on time windows (moving averages, moving correlations, min-max etc.) is that they require decisions on the optimum window length. As described earlier, these decisions are based on weighing the detailed information provided by short time windows over the reliability provided by longer ones. The decision on window length is not a purely statistical or technical matter, however. When true fluctuations occur in some phenomenon or relationship among variables, the window length should correspond with the time scale of the fluctuations, and as long as the time scale of the fluctuations is not known, it is hard to decide on the length of the corresponding window of...
observation. However, the only way to solve this equation with two unknowns is through an iterative procedure of empirical trial-and-error.

Overall, dynamic systems methods seem a complex but promising technique for studying processes of change in a clinical context, and can provide insight into individual trajectories of change over the course of treatment, using both statistical tests and visual techniques.

4.3 Considerations

Obviously, the small number of subjects precludes firm conclusions to OCD patients in general. However, small scale studies can shed light on how change can unfold over time, which is often overlooked in large group studies (Borckardt, Nash, Murphy, Moore, Shaw & O’Neil, 2008). In their plea to conduct small sample studies, Borckardt et al. (2008) point out that the APA’s Division 12 Task Force on Promotion and Dissemination of Psychological Procedures (2001) has recognized time-series designs as important methodological approaches that can fairly test treatment efficacy, and that the APA Task Force on Evidence-Based Practice (2005) has endorsed systematic single case studies as contributing to effective psychological practice. They conclude that time series designs alongside group designs can contribute to our understanding of the structure and mechanism of change in therapy (Borckardt et al., 2008).

In spite of the special case formulation session that was dedicated specifically to constructing the diary in dialogue with the participant, it appeared that sometimes it was hard for participants to link the dysfunctional beliefs in the diary to the thoughts they actually had. Explicit measures to assess beliefs are limited by what a participant is willing and able to report. Furthermore, self-monitoring can have a treatment effect (e.g., Storchheim & O’Mahony, 2006). Since we applied a new statistical technique, we chose not to include implicit measures in order to keep things relatively simple (i.e., with respect to process variables). However, future research might benefit from including implicit measures of process variables such as the Affective Simon Task (De Houwer & Eelen, 1998; Weertman, Arntz, De Jong & Rinck, 2008). This type of measure circumvents the introspective limits of the traditional self-report measures and taps into relevant associations that are not readily susceptible to introspection (e.g., Huijding, 2006). Furthermore, assessment of idiosyncratic beliefs might better be started after the first two sessions, when participants have been properly introduced with the cognitive-behavioural model and probably have a better grasp of what is meant by credibility of a dysfunctional belief.

Furthermore, therapists within this study were master students in clinical psychology, which has advantages as well as some disadvantages. In general, student therapists usually prepare treatment sessions very well, reflect on the treatment in supervision, and tend to follow the treatment manual very carefully. On the other hand, they do not have the same repertoire of therapeutic problem-solving
techniques. Nonetheless, therapists can learn to meet specific levels of competence through structured supervision and systematic feedback, and the use of treatment manuals facilitates training these skills (Wilson, 1996). Moreover, results of a clinical trial showed that ERP delivered by master students was equally effective as ERP delivered by experienced behaviour therapists, indicating that the treatment manual is more important than level of experience of the therapist (Van Oppen, Van Balkom, Smit, Schuurmans, Van Dyck & Emmelkamp, in press). Considering treatment results – six out of seven participants improved significantly, and four of those also showed clinically significant improvement- we can conclude that, in general, the limited experience of our therapists did not hinder treatment efficacy.

Finally, some remarks have to be made concerning the assessment of OC symptomatology. First of all, large differences in clinical significance between Y-BOCS and PI-R were found. However, previous studies also reported low correlations between the Y-BOCS and the PI-R, suggesting that both measures assess different features of OCD (e.g., Van Oppen, Emmelkamp, Van Balkom, & Van Dyck, 1995c). Secondly, we did not distinguish between practised and spontaneous behaviour in our process variables. Even though cognitive treatment only involves few behaviour experiments this might be beneficial in future studies especially when cognitive treatment is combined with ERP.

4.4 Conclusion
Although the small sample size of this study precludes generalization to OCD patients in general, it highlights the importance of studying processes of change during treatment. From a theoretical perspective, this study showed that changes in dysfunctional beliefs are associated with effective CT for OCD. However, patterns of change within successfully treated patients can vary dramatically: Decreases in symptom severity can take place early during treatment and in combination with changes in other variables like anxiety and compulsions, which are considered to be related according to the cognitive–behavioural model. However, a successful treatment effect can also be obtained along a different road not in line with the predictions of the cognitive–behavioural model. This is in accordance with findings of earlier process studies showing that the relationship between changes in beliefs and compulsions was bi-directional (e.g., Rhéaume & Ladouceur, 2000). The available evidence suggests that the clinical reality is more complex than the cognitive–behavioural model of OCD implies. This is consistent with earlier research showing that OC beliefs only seemed to be relevant to half of the participants of two large OCD patient samples (Calamari, Cohen, Rector, Szacun-Shimizu, Riemann, & Norberg, 2006; Taylor, Abramowitz, McKay, Calamari, Sookman, Kyrios, et al., 2006).

Furthermore, this study demonstrated how statistical techniques based on dynamic systems theory can provide insight into intra-individual processes of change during treatment. These techniques can capture discontinuous patterns of
change, thereby providing information on an intra-individual level, which enables comparison between individuals which can be linked to treatment outcome (level of improvement). Furthermore, these techniques and its underlying theory provide a new perspective on the meaning of variability. Future studies should elaborate on the use of formal tests to investigate processes of change. Rather than using outcome studies as an argument for the validity of the cognitive-behavioural model, process studies such as the one at hand, can be designed to follow the exact course of pivotal variables over time. Optimally, process research could provide information for how to bring about change in different patients.