Belief biased reasoning in anxiety disorders
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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2011

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
General discussion
Patients suffering from anxiety disorders seem to hold on to their anxiogenic dysfunctional convictions in the face of disconfirming evidence. This failure to correct anxiogenic dysfunctional convictions can be explained by looking at the patients’ reasoning style. Correcting erroneous convictions requires that people accurately deduce the logical implications of empirical evidence for their beliefs. It is well established that people in general have difficulty to reason according to the rules of logic when reasoning with materials they strongly believe in. This effect is known as the belief bias effect. Anxiety disorder patients believe strongly in their anxiogenic dysfunctional convictions. Therefore, belief bias can logically be assumed to be involved in sustaining anxiogenic dysfunctional convictions in anxiety disorders.

Previous research in the context of spider phobia (de Jong, Weertman, Horseelenberg, & van den Hout, 1997) provided preliminary evidence to suggest that belief bias in anxiety disorders can take two forms: First, belief bias may be evident in the domain of disorder-related convictions. Such a domain-specific belief bias represents a reasoning process that is in itself not deviant, but becomes counterproductive because it helps to sustain convictions that are at the core of anxiety disorders. Second, a strong belief bias might (also) be a general cognitive characteristic of individuals suffering from anxiety disorders, exerting its influence on symptom-irrelevant domains as well. The presence of such a generally enhanced belief bias may be indicative of a trait-like information processing bias that acts as a diathesis in the development of anxiety disorders.

The present thesis set out to explore the potential role of belief bias in anxiety disorders. The examination followed two lines: The first line focussed on investigating whether a generally enhanced belief bias is involved in the development of anxiety disorders. The second line focussed on determining both the specificity of the domain-specific belief bias effect (viz. being indeed disorder bound) and the generality of this effect over various anxiety disorders. In the present chapter, a summary of the empirical studies (Chapters 2 to 6) will be given. These will then be discussed with respect to the two research lines. Limitations, future research and relevance will also be discussed.

**Summary of the empirical chapters**

**Generally enhanced belief bias in a general sample**

The finding of a generally enhanced belief bias in spider phobic patients (de Jong, Weertman et al., 1997) could either represent an epiphenomenon of anxiety disorders, or it could indicate that generally enhanced belief bias contributes to the development of an anxiety disorder such as spider phobia. If generally enhanced belief bias is indeed related to the development of anxiety
disorders, a relationship between the strength of belief bias and level of anxiety symptoms can already be evident in a non-clinical sample. To test this notion, in the study reported in Chapter 2, a large sample of students was subjected to a belief bias task. In this task neutral syllogisms were presented (e.g., ‘An elephant is bigger than a dog, a dog is bigger than a mouse, therefore an elephant is bigger than a mouse’), as well as general threat related syllogisms (e.g., ‘Long cancer is more dangerous than pneumonia, pneumonia is more dangerous than the flu, therefore long cancer is more dangerous than the flu) and general safety related syllogisms (e.g., ‘The Netherlands are safer than Russia, Russia is safer than Afghanistan, therefore the Netherlands are safer than Afghanistan’). General threat- and general safety-related syllogisms have not previously been studied in the context of anxiety. Since it was assumed that the relationship between belief bias and anxiety symptoms would be less pronounced in a general population, we hoped that adding threat and safety components to the reasoning materials would facilitate the detection of this relationship: It is likely that specifically participants who show enhanced confirmation of threatening information (as indexed by a threat related belief bias) or enhanced disconfirmation of safety-related information (as indexed by a reversed safety related belief bias effect) will be particularly at risk for the development of anxiety disorders, which may result in developing anxiety symptoms more easily. No relationship between belief bias as measured with general threat-related, general safety-related, or neutral syllogisms and anxiety symptoms was found. In this study however, no control had been exerted over the amount of anxiety-inducing learning experiences. Anxiety-inducing learning experiences may be a critical moderating factor in the relationship between belief bias and anxiety symptoms: A belief-confirming reasoning strategy can serve to consolidate anxiogenic beliefs only if people have experienced situations that could have lead to such anxiogenic convictions.

In Chapter 3, anxiety-related learning experiences were brought under experimental control in an attempt to show that indeed belief bias is related to the development of anxiety symptoms. It was assumed that a heightened belief bias would delay the extinction of shock expectancies. In the first of two experiments, participants (students) initially learned to expect an aversive shock following one of two abstract figures. In this acquisition phase, the shock always followed after one of the figures (CS+) and never after the other figure (CS). After having learned this relationship, the shock was no longer administered after the presentation of the CS+ (nor after the presentation of the CS). Participants had to indicate the probability that a shock would follow on each CS-presentation. General belief bias was measured prior to the fear conditioning procedure with the use of neutral syllogisms. As expected, in the
acquisition phase shock expectancies increased for the CS+ and decreased for the CS. In the extinction phase, shock expectancies for the CS+ decreased, resulting in a decreased differential UCS expectancy between the CS+ and the CS-. We had expected to find that differences in UCS expectancies between the CS+ and the CS in the extinction phase would be more pronounced for participants with stronger general belief bias. We did not find such positive correlations when belief bias was indexed by errors, and we even found negative correlations with belief bias when belief bias was indexed by RTs. We argued that this unexpected result could have been caused by a lack of intrinsic relatedness of the CS+ to the shock: This lack may have led participants to form less strong beliefs about the CS+ and the shock belonging together. Less strong beliefs do not facilitate belief biased reasoning. If anything, as the initial beliefs go against any relationship concerning the CS+ and the shock, belief bias will work to confirm that indeed the CS+ and the shock did not belong together. This may result in speeded extinction of UCS expectancies. The second experiment therefore used stimuli that were intrinsically related to the UCS (a cactus and a sunflower) to test the alleged relationship. For half of the participants the cactus served as CS+ (high belongingness condition) and for half the sunflower served as CS+ (low belongingness condition). Apart from these differences, the design was similar to that of Exp.1. In the high belongingness condition, the differences in UCS expectancies between the CS+ and the CS in the extinction phase were indeed more pronounced for participants with stronger general belief bias (as indexed by errors). For the low belongingness condition, no correlations emerged. Based on these results, it was concluded that indeed belief bias may play a role in the delay of UCS expectancy extinction, and that this experiment functions as a model for how generally enhanced belief bias may indeed be involved in the development of anxiety disorders through the consolidation of fear expectancies.

Domain-specific and generally enhanced belief bias in patients and analogue samples

In Chapter 4, domain-specific as well as generally enhanced belief bias was tested in panic disorder (PD) patients. To be able to determine whether domain-specific belief bias was indeed specific for patients suffering from PD, a clinical control group consisting of obsessive-compulsive disorder (OCD) patients was included in the study. To be able to determine potential differences in general belief bias, a non-clinical control (NCC) group was also included. Participants were tested for domain-specific belief bias, which in the present study comprise PD-related belief bias, as well as generally enhanced belief bias. After they had completed the belief bias task, the participants were asked to rate the believability of the conclusion of every syllogism. With respect to the conclusions that were rated on believability, the PD related conclusions were rated as
equally believable by all groups. This is remarkable given that these had been
designed to match PD related convictions. With respect to the belief bias task,
the error data could not be taken into consideration due to severe skewness. The
analyses were therefore restricted to the RT data. For the domain-specific
syllogisms, there was a marginally significant group difference. Remarkably,
although the PD group indeed displayed domain-specific belief bias, so did the
OCD group. The ‘domain-specific’ belief bias was even stronger in the OCD
group than in the PD group. Together with the unexpectedly high believability
ratings for the PD-related conclusions in the OCD and NCC groups, these
findings raise the question of whether the domain-specific syllogisms were
indeed specific to PD convictions. The conclusion with respect to the specificity
of the domain-specific belief bias effect was therefore postponed.

The groups did not differ in their levels of general belief bias (as indexed by
RTs). This finding does not support the notion of anxiety disorder patients being
characterised by a generally enhanced belief bias.

The studies focussing on spider phobia (de Jong, Weertman et al., 1997) and PD
(Chapter 4) made clear that spider phobic and PD convictions are hard to
translate into linear syllogisms. In an attempt to improve the specificity of the
reasoning task, we focused in Chapter 5 on an anxiety disorder for which beliefs
are easier to translate into linear syllogisms: Social anxiety disorder (SAD)
patients are overly concerned with how they perform in comparison to other
people. This comparison component better suits the form of linear syllogisms, as
linear syllogisms consist of a comparison between three components (and a
comparison of two of these components in the conclusion). Thus, social anxiety
convictions were targeted. Eight social anxiety related syllogisms were
constructed (e.g., ‘Others find me less capable than person A, other find person
A less capable than person 1, therefore others find me less capable than person
1’).

To test whether indeed these newly created social anxiety-related syllogisms
match social anxiety symptoms, we tested for a relationship between social
anxiety-related belief bias and social anxiety symptoms in a non-clinical sample:
Participants were students with varying levels of social anxiety (ranging from
very low to high on the Fear of Negative Evaluation scale). The participants
completed a belief bias task comprising neutral and social anxiety related
syllogisms. Due to skewness of the error data, only the RT data could be used in
the analyses. As expected, domain-specific (viz. in the present study social
anxiety related) belief bias was positively related to levels of social anxiety:
Participants with higher levels of social anxiety also showed more domain-
specific belief bias. This underlines the usefulness of the newly developed social
anxiety-related syllogisms to measure domain-specific belief bias in SAD patients.

No relationship was found between general belief bias and social anxiety symptoms. Taken together, these findings support the notion that belief bias may be involved in the maintenance of SAD through the maintenance of anxiogenic dysfunctional convictions, but do not support the notion that SAD patients are characterised by a generally deviant reasoning strategy.

A believability check of the syllogisms’ conclusions revealed that the perceived believability of the social anxiety related conclusions was indeed related to the level of social anxiety. The results from both the belief bias task and the believability check underline the successful translation of anxiogenic dysfunctional convictions into syllogisms, although the believability ratings show that there is still room for improvement.

After having successfully translated social anxiety convictions into syllogisms, this measure of domain-specific belief bias was put to the test in a SAD patient group: In Chapter 6, SAD patients were tested for the presence of domain-specific (viz. in the present study social anxiety related) belief bias. The specificity of this domain-specific belief bias was tested by comparing SAD patients with PD patients. Domain-specific belief bias was measured with the social anxiety-related syllogisms developed in Chapter 5. The believability of the social anxiety-related syllogisms was checked by having patients rate the believability of all social anxiety-related conclusions. General belief bias was also measured and performance of both patient groups was compared to the performance of a NCC group. The results presented in this chapter are preliminary, as the inclusion of participants in the NCC group is still ongoing (n = 16 at present). As expected, the SAD group displayed belief bias concerning social anxiety-related syllogisms. Contrary to expectations, the SAD and the PD group did not significantly differ in their level of ‘domain-specific’ belief bias as indexed by RTs, although the effects are in the expected direction: On average, the PD group displayed no belief bias whereas the SAD group did. No effects of domain-specific belief bias were found when indexed by errors. With respect to the believability of the social anxiety-related syllogisms, the SAD patients rated the social anxiety-related conclusions as more believable than the PD patients and the NCCs. The ratings by the SAD group showed only moderate believability, indicating that there is still much room for improvement. Together these results do not support the notion that domain-specific belief bias is in content disorder-unique, and give rise to the interpretation that the domain-specific belief bias is caused by the anxiety state of anxiety disorder patients. Yet, had the ‘domain-specific’ belief bias effect represented a general effect of anxiety, this would have likely spilled over to neutral syllogisms. This did not
happen. An alternative interpretation that should be taken into consideration is that the only moderate believability of the domain-specific syllogisms for the SAD group may have limited the sensitivity of the task to detect differences between groups.

With respect to general belief bias, there were no group differences when comparing belief bias as indexed by RTs. The groups did differ significantly for general belief bias as indexed by errors: The results seem to indicate that the PD patients display more general belief bias than the SAD patients and the NCCs. These differences did however not meet the required level of significance when correcting for type I error. Differences between the PD and the NCC group may emerge when the inclusion of NCC participants is completed.

In Table 7.1, an overview is given of the most relevant findings of the present series of studies. In the following part, the results of these studies will be combined to answer the research questions of this thesis. First, the question regarding the involvement of belief bias in the development of anxiety disorders will be discussed. We will continue with discussing the specificity and the generality of the domain-specific belief bias.

**Involvement of belief bias in the development of anxiety disorders**

In a first study investigating the relationship between belief bias and psychopathology, de Jong, Weertman et al. (1997) found that spider phobic patients show an enhanced belief bias for neutral materials compared to non-anxious controls. It was argued that this generally enhanced belief bias may be a trait-like reasoning bias contributing to the development of the spider phobia. It was assumed that particular learning experiences may lead to the formation of dysfunctional convictions and that a generally enhanced belief bias would prevent the refutation of these convictions, and would even strengthen them, thereby fuelling the development of an anxiety disorder. In this thesis the extent to which this interpretation holds true was studied.

We were unable to relate neutral belief bias to anxiety symptoms in a general student sample in Chapter 2, which is in line with earlier findings from a non-clinical sample in which only neutral syllogisms were used (Smeets & de Jong, 2005). We had expected that introducing themes regarding threat and safety into the syllogisms would facilitate the detection of a relationship between belief bias and anxiety symptoms in a non-clinical sample. However, no correlations were found between general threat- and general safety-related belief bias and anxiety symptoms. When using a different approach, by bringing learning experiences under control in a differential fear conditioning paradigm in
Chapter 7

Chapter 3, we found evidence that belief bias is related to the rate of extinction of UCS expectancies in a normal student sample. The fear conditioning task in our study modelled the development of an anxiety disorder; the finding that larger belief bias effects are related to delayed extinction supports the notion that belief bias may be involved in the development of anxiety disorders. The lack of correlations between belief bias and the acquisition of differential UCS expectancies suggests that belief bias may not be involved in the initial development of an anxious expectation. However, a lack of extinction of such an anxious expectation may turn this expectation into an anxiogenic conviction. Such anxiogenic (dysfunctional) convictions are at the core of anxiety disorders. The support for the notion that belief bias is involved in the development of anxiety disorders would have been stronger, had we also found correlations between belief bias and speeded acquisition. One way to enhance the sensitivity for individual differences in acquisition learning (as well as in extinction learning) would be to include multiple stimuli in the design and to reduce the CS+/UCS contingency. This may help detect correlations between belief bias and acquisition of initial anxious expectations.

Table 7.1
Overview of the most relevant findings in the present thesis

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<thead>
<tr>
<th>Chapter</th>
<th>Generally enhanced belief bias</th>
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<td>Chapter 4</td>
<td>PD pt’s, OCD pt’s, NCCs</td>
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<td>Chapter 5</td>
<td>student sample</td>
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<td>Chapter 6</td>
<td>SAD pt’s, PD pt’s, NCCs</td>
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* Only the high belongingness condition of Exp.2 is discussed  

** not included in the design
The results from the studies reported in Chapter 3 may help explain why the relationship between belief bias and anxiety symptoms was not evident in Chapter 2, nor in the previous study by Smeets and de Jong (2005): The series of studies in Chapter 3 showed that it was indeed helpful to bring learning experiences under control to enhance the sensitivity for the assumed relationship. The findings from the studies in Chapters 2 and 3 suggest that belief bias itself does not contribute to the development of anxiety disorders, but that belief bias combined with certain anxiety-inducing learning experiences can. It should be noted that we only found limited evidence for the presence of a generally enhanced belief bias in our patient groups. This finding indicates that even if belief bias (combined with anxiety-inducing learning experiences) is involved in the development of anxiety disorders, it is likely only one of many factors that contributes to the development of anxiety disorders. Also, the absence of consistent and strong findings regarding generally enhanced belief bias in our patient groups indicate that belief bias is by no means a prerequisite for developing an anxiety disorder.

Table 7.1  
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<th>Chapter</th>
<th>Domain-specific belief bias</th>
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*This index could not be analysed  
*This effect was marginally significant (with n = 16 for NCC)*
The relationship between belief bias and rate of extinction of UCS expectancies in Chapter 3 was only evident for belief bias as indexed by errors. When belief bias expresses itself in RTs, this indicates that participants have successfully completed the reasoning process: Participants have correctly noticed and corrected their initial tendency to rely on the believability instead of the logical validity of the information. On the other hand, when belief bias is expressed by errors, this indicates that the participant has relied on heuristic processing (System 1 processing) and erroneously relied on the believability to determine logical validity. This means that System 2 (analytical reasoning) was less (or not) involved (cf. e.g., Evans, 2003). It should be noted that participants can draw the wrong conclusion even when they do engage in System 2 reasoning and let this reasoning prevail. System 2 reasoning guarantees analytical reasoning, but it does not guarantee correct outcome (Evans, 2003).

While we found indications for a generally enhanced belief bias to be related to delayed extinction of UCS expectancies (Chapter 3), we did not find evidence for the presence of a generally enhanced belief bias in PD or OCD patients (Chapter 4). It should be noted that we only found enhanced belief bias as indexed by errors to be related to delayed extinction of UCS expectancies. If indeed the relationship between generally enhanced belief bias and anxiety disorders is only evident for belief bias as indexed by errors, this may well explain why no evidence for a generally enhanced belief bias was found in PD or OCD patients in Chapter 4: In the study reported in Chapter 4, the distribution of the error data did not meet requirements for general linear modelling (nor could the data be analysed non-parametrically, due to the complexity of the design). The error data could therefore not be analysed. In the other patient study of the present thesis (Chapter 6), the distribution of the error data did allow us to analyse belief bias as indexed by errors, and here indeed we did find evidence for a generally enhanced belief bias to be related to anxiety disorders. Although the group differences in belief bias cannot yet be attributed to any particular group (likely due to current sample sizes), there are some indications that PD patients but not SAD patients display a generally enhanced belief bias as indexed by errors. In this study too, no relationship between generally enhanced belief bias and anxiety disorders was found when belief bias was indexed by RTs.

In apparent contrast with this, the initial finding of a generally enhanced belief bias in spider phobic patients (de Jong, Weertman et al., 1997) was evident in RTs. The error data could not be analysed in this spider phobia study due to a lack of variation, so it remains unclear whether the spider phobic patients differed from the non-phobic controls in general belief bias as indexed by errors. De Jong, Weertman et al. (1997) were the only ones to find effects for generally enhanced belief bias when belief bias was indexed by RTs. This may
be due to a difference in task design between the initial spider phobia study of de Jong, Weertman et al. (1997) and the studies reported in the present thesis. In the spider phobia study, considerably more time was left between the presentation of the syllogisms than in the present series of studies, which may have resulted in a lesser sense of urgency for participants in the spider phobia study. A sense of urgency will decrease System 2 reasoning. Thus, compared to the participants in the spider phobia study, participants in the studies reported in this thesis will have relied more on System 1 processing. Hence, these participants will have made more belief biased reasoning errors (as compared to the participants in the spider phobia study, who probably could make better use of System 2 reasoning and were thus better able to correct their initial belief bias tendencies). This may explain why a generally enhanced belief bias in the initial spider phobia study was evident when belief bias was indexed in RTs. Of course, this post hoc explanation needs further testing in order to be validated. The differences in meaning of belief bias indexed by RTs and indexed by errors will be discussed later on in this chapter.

The results from the studies reported in the present thesis indicate that a generally enhanced belief bias is present in some but not all anxiety disorders. At present, the findings indicate that spider phobic patients as well as PD patients can be characterised by a generally enhanced belief bias, whereas SAD patients cannot. Assuming that, in the studies reported in this thesis, a generally enhanced belief bias will only become evident when indexed in errors, we can make no assumptions about the role of generally enhanced belief bias in OCD patients (since errors could not be analysed in Chapter 4). This interpretation should however be taken with caution: That a relationship between generally enhanced belief bias and (the development of) anxiety disorders will only express itself when belief bias is indexed in errors in the present series of studies is merely a post hoc explanation. Future studies need to confirm whether indeed the present set-up and instructions of the belief bias task results in the detection of this relationship only when belief bias is indexed by errors.

The finding of differences in general belief biased reasoning performance over various anxiety disorders points to the possibility of generally enhanced belief bias being differentially involved in various anxiety disorders. The finding that generally enhanced belief bias was related to extinction of UCS expectancy points to the relevance of belief bias in the development of specific phobia, since we induced fear for a single stimulus in this study. Given the potentially differential contribution of generally enhanced belief bias to various anxiety disorders, we cannot confidently conclude from this that the same holds for the development of other anxiety disorders such as PD. Therefore, it would be advisable to design disorder specific lab models to test for the contribution of
belief bias to the development of each of the anxiety disorders. For instance, as a laboratory model for the development of PD, a fear conditioning paradigm could be used in which false heart rate feedback is paired with air puffs containing high CO₂ concentrations (cf. Stegen, De Bruyne, Rasschaert, Van de Woestijne, & Van den Bergh, 1999).

**Specificity and generality of the domain-specific belief bias effect**

*Translation of anxiogenic dysfunctional convictions into domain-specific syllogisms*

The results from the present series of studies indicate that the translation of anxiogenic dysfunctional convictions into domain-specific syllogisms has been problematic and may have hampered a proper interpretation of the results. Before answering the question regarding the specificity and the generality of the domain-specific belief bias effect, we therefore first address the problem concerning the translation of anxiogenic dysfunctional convictions into syllogisms.

Similar to the spider phobia study (de Jong, Weertman et al., 1997), Chapter 4 reports on the difficulties in creating linear syllogisms that match anxiogenic dysfunctional convictions of PD patients. In the study reported in Chapter 4, we measured the believability of the syllogisms’ conclusions. If the domain-specific syllogisms are indeed specifically designed to match the anxiogenic dysfunctional convictions of the patient group that was targeted, believability of the conclusions should be high for the targeted patient group but not for other participants. Thus, with respect to the study reported in Chapter 4, if the PD-related syllogisms were specifically designed to match PD-related dysfunctional convictions, PD patients but not NCCs or OCD patients should rate the conclusions of these syllogisms as highly believable. In this study it was however found that all three groups rated the PD-related conclusions as very believable. Indeed, conclusions of syllogisms such as ‘A spider is creepier than a fish, a fish is creepier than a pigeon, therefore a spider is creepier than a pigeon’ (de Jong, Weertman et al., 1997) or ‘Gasping is scarier than a dark cellar, a dark cellar is scarier than a romantic movie, therefore gasping is scarier than a romantic movie’ (Chapter 4) seem generally believable. In an attempt to better match anxiogenic dysfunctional convictions and syllogisms, we successfully turned our attention to social anxiety (Chapter 5). The better match between anxiogenic dysfunctional convictions and domain-specific syllogisms was supported by the findings presented in Chapter 6, showing that NCCs did not display belief bias for social anxiety-related syllogisms. Believability ratings confirmed that NCCs and also PD patients considered the social anxiety related
conclusions mildly unbelievable, and that the SAD patients considered the conclusions mildly believable (scoring on average 20.5 on a scale of −100 to 100, whereas the PD group scored −12 for believability and the NCC group −14.5). These believability ratings indicate that although the translation was successful, there is still much room for improvement. Also, the lack of a group difference for domain-specific belief bias between the SAD and the PD group can be interpreted as a lack of fit between the social anxiety convictions and the syllogisms. Thus, linear syllogisms are likely not ideally suited to convey disorder related convictions. Other options should therefore be explored.

Belief bias has typically been studied in student groups by means of categorical syllogisms such as ‘No addictive substances are cheap, some cigarettes are cheap, therefore some cigarettes are no addictive substances’ (Evans, Newstead et al., 1993). As de Jong, Weertman et al. (1997) argued, categorical syllogisms are hard to solve, even for students, making them less suitable to measure belief bias in the general population. It is therefore wise to look for alternative ways to measure belief bias. Anxiogenic dysfunctional convictions often hold an ‘if ..., then...’ form: ‘If I feel palpitations, I will have a heart attack’, ‘If I blush, people will ridicule me’, ‘If I don’t wash my hand, my mother will die’. Causal conditional reasoning (‘if P, then Q’, see e.g., Evans, Newstead et al., 1993) might therefore provide a more optimal means to measure belief bias.

In a study which is not reported in the present thesis, we made a first attempt to measure belief bias with causal conditionals. In this study, we relied on the definition and consequences of belief bias instead of the original design of belief bias tasks: Belief bias refers to holding on to one’s conviction when presented with disconfirming information. We therefore presented participants (students) with believable causal inferences (e.g., ‘Conditional: If the brake is being pushed, the car slows down; Fact: The brake is being pushed; Conclusion: The car slows down’), of which the participants rated the credibility of the conclusions given the conditionals and facts on a visual analogue scale (0-100). After a break, the participants were presented with exactly the same conditionals, yet this time new information was added to the fact, which may prompt people to think of alternative interpretations (e.g., ‘Conditional: If the brake is being pushed, the car slows down; Fact: The brake is being pushed and the brakes are not broken; Conclusion: The car slows down’). Again, the participants had to rate the credibility of the conclusions. Logically speaking, the inclusion of the new information should not change the credibility of the conclusion, but people are known to change their evaluation of the conclusion in light of this new information. Indeed, it was found that participants changed their credibility ratings, either towards becoming more convinced (as we had eliminated one of the possible alternative interpretations or disabling situations;
cf. Cummins, Lubart, Alksnis, & Rist, 1991) or towards becoming less convinced (as we had seduced people to consider additional information with respect to the conditionals; cf. De Neys, Schaeken, & D’Ydewalle, 2003). It was expected that participants who show high levels of belief bias as measured with syllogisms would show a relative lack of change in credibility on the present conditional reasoning task (when comparing the credibility of the regular conditionals with the credibility of the conditionals in which additional information was presented). We correlated the amount of change in credibility with an original measure of belief bias to be able to determine whether indeed the newly developed conditional reasoning task measures belief bias. No correlations between the amount of change on the new reasoning task and the original belief bias measure were found in this initial exploratory study, indicating that, in its present form, this design does not provide a valid measure for belief bias (Abbink, 2007). Future studies should seek to increase the sensitivity of this newly developed task. Perhaps inspiration for the increase of sensitivity can be gained from a recent study in which causal conditionals were successfully used to create an interaction between believability and logical validity (Evans, Handley, Neilens, & Over, 2010).

**Specificity and generality of the domain-specific belief bias effect**

The patient studies described in Chapters 4 and 6 show that the effect of a disorder-related belief bias is not only evident in spider phobic patients, but also in PD patients and patients suffering from SAD. Theoretically, a disorder-related belief bias is expected to be evident in all disorders for which anxiogenic dysfunctional convictions play an important role. The present findings lend support to the idea that disorder-related belief bias can indeed be found in various anxiety disorders. We could conclude from this that generality of the effect is indeed in order. However, it still remains to be seen whether disorder-relevant belief bias is indeed restricted to the relevant disorder.

The finding that, in the present series of studies, not only the PD group but also the OCD group displayed PD-related ‘domain-specific’ belief bias, and that not only the SAD group but also the PD group displayed social anxiety related ‘domain-specific’ belief bias, leads to questioning either the domain-specificity of the syllogisms (as was discussed above) or the domain-specificity of the belief bias effect, or both. Co-morbidity can be ruled out as potential explanation as we had defined the presence of the primarily targeted disorder (viz. PD in Chapter 4 and SAD in Chapter 6) as an exclusion criterion for the clinical control groups (viz. OCD in Chapter 4 and PD in Chapter 6). If the domain-specific belief bias is not restricted to the relevant disorders, but to suffering from an anxiety disorder in general, the domain-specific belief bias effects might have been caused by anxiety itself. One can imagine that reasoning with anxiety-related
materials (e.g., social rejection or spiders being scary) may have an enhanced content-effect for those participants who initially experienced higher levels of anxiety (viz. the patient groups). Most likely, if indeed the emotionality of the content would have induced a heightened level of anxiety in our patients, such detrimental effect of anxiety\textsuperscript{22} would have spilled-over to the neutral syllogisms as well. Yet, we did not find similar effects on the neutral syllogisms. Note that we did find some differences between groups in general belief bias, but that these differences are not similar to the differences in domain-specific belief bias effects. It seems therefore most parsimonious to assume that, once an adequate domain-specific belief bias measure has been developed, the domain-specific belief bias will prove to be domain- (or disorder-) specific indeed. It is expected that this effect will be evident in all anxiety disorders (although strength may vary over the various anxiety disorders, depending on the role of anxiogenic dysfunctional convictions within each disorder). Most likely, the domain-specific belief bias will prove to consist of a normal process that backfires because of its deviant input (namely the anxiogenic dysfunctional beliefs).

Reaction times vs. errors in belief bias

In the present series of studies, belief bias was indexed by both errors and RTs. Originally, studies investigating belief bias have only focussed on the distribution of errors between matches and mismatches in categorical syllogistic reasoning tasks. As categorical syllogisms are hard to solve even for students (cf. de Jong, Weertman et al., 1997), we have used linear syllogisms to be able to measure belief bias in a general population. By doing so, we chose to include RTs as an index for belief bias: Linear syllogisms generally elicit only few errors when evaluated for logical validity when there are few time constraints (e.g., Huttenlocher, 1968), making errors a less reliable outcome measure for belief bias (in which the differences in errors between cells needs to be evaluated). With the inclusion of RTs to index belief bias, we were able to detect belief bias even when people made no mistakes: When people have relatively more

\textsuperscript{22} It should be noted that Mancini and colleagues oppose this view of a detrimental effect of anxiety. They argue that patients perform more adequate reasoning compared to controls when reasoning with disorder-relevant materials. They base this interpretation on results of a study in which syllogisms were presented that were either valid or invalid, but that were always believable. This design does not allow to differentiate between better reasoning performance and belief biased reasoning: If their interpretation is correct, patients would also perform better on valid-unbelievable syllogisms. These syllogisms were not included in the reasoning task (Mancini, Gangemi, & Johnson-Laird, 2008, July). The data of the present thesis consistently contradict the notion that patients would have performed better on valid-unbelievable syllogisms.
difficulty to solve mismatched syllogisms but do so accurately anyway, they will likely show a delayed response on these more difficult syllogisms (Evans, 2003).

In an attempt to force people to show their belief bias on the easier-to-solve linear syllogisms, instructions were used that stressed both the need for accuracy (to ensure that people actually engaged in logical reasoning performance) and the need for rapid response (to enhance differences in RTs between the easier and the more difficult syllogisms). In doing so, we have created ambiguous instructions: People need to choose between being accurate and being fast. Wanting to be accurate will induce System 2 processing, in which belief bias is more likely to be overcome with respect to correct outcome of the reasoning process (e.g., Dickstein, 1975), whereas wanting to be quick will induce System 1 processing, in which beliefs will be an important guide for the evaluation of the syllogisms (e.g., Evans & Curtis-Holmes, 2005). We cannot be certain how people handled this discrepancy. Most likely, they have tried to find some middle ground. We know that participants did not solely rely on being quick, given that the average reaction times often lie around 7 seconds or more and that, generally, more syllogisms were solved correctly than incorrectly in each cell of the design. This contradicts the notion that participants did not engage in a reasoning process. Yet, the exact balance people found in this speed-accuracy trade-off remains unclear. Also, this balance may have varied between participants as well as within participants (for instance after participants were reminded of the instructions after a break in the reasoning task, or due to increasing fatigue over the course of the reasoning task).

The speed-accuracy trade-off does not appear to be stable over the various studies: For instance, in one of our studies, belief bias error scores correlated with belief bias error scores between domains, indicating a stable speed-accuracy trade-off for all types of syllogisms. In another study, all belief bias scores (both error-based and RT-based for neutral, threat and safety domain) correlated with each other, indicating an overall stable approach. In yet another study, no correlations between belief bias scores as indexed by errors or by RTs and the various domains were found (which could be taken as a sign of varying speed-accuracy trade-off). Even though the exact nature of the speed-accuracy trade-off in the present series of experiments remains unclear and hinders the interpretation of the differences between results found for belief bias as indexed by either errors or RTs, this need not lead to mistrusting our findings: RTs were relatively high, even for matched syllogisms, and error rates were on average low, even for mismatched syllogisms. These findings indicate that people overall did not consequently rely solely on System 1 processing. Also, in all studies we found clear interaction effects between believability and validity, albeit that we sometimes found it for both errors and RTs and sometimes for only RTs or
errors. This shows that although there is indeed a trade-off, the tasks were sensitive enough to measure belief bias effects.

Belief bias as indexed by errors is clearly the most overt threat to the disconfirmation of beliefs: Participants who engage in faulty, belief-confirming, reasoning under relatively ideal conditions (e.g., although we did include time pressure, the maximum response time was 20 seconds, and reasoning took place in a single-task setting) will likely show at least the same level of belief bias in everyday situations. In future research, if one wants to detect those people most at risk for confirmation of (anxiogenic dysfunctional) beliefs, then instructions need to induce participants to make great effort to come up with the correct answer. Therefore, instructions would need to stress accuracy. By doing so the sensitivity of the belief bias task will diminish. Therefore, if one wants to be able to detect even small levels of belief biased reasoning, then belief bias should be facilitated by stressing rapid responding in the instructions. However, by doing so, one risks that participants will only rely on believability and will not commit to any effort of reasoning.

**Future research**
The series of studies in the present thesis of course give rise to suggestions on improvement of previously conducted studies and to new research questions. These will be discussed here. First, as discussed earlier, it is important to find better ways to measure domain-specific belief bias in order to be able to successfully continue the research into the specificity and generality of domain-specific belief bias in anxiety disorders. Hopefully causal conditional reasoning will prove useful in this context. Second, it would be wise to use unambiguous task instructions to avoid confusion in the meaning of belief bias as indexed on errors versus as indexed on RTs.

Until now, the role of domain-specific belief bias as a maintaining factor for anxiety disorders has only been logically derived. Future studies should set out to empirically test the alleged causal influence of disorder-relevant belief bias in the maintenance of symptoms. In order to do so, domain-specific belief bias in one group of patients should be experimentally reduced while a second group of patients receives no manipulation of belief bias (cf. Amir, Weber, Beard, Bomyea, & Taylor, 2008 for a similar approach in the context of attentional bias). How a reduction of belief bias can be achieved will be discussed later on in this paragraph.

In a similar vein, it would be important to test further the alleged causal influence of generally enhanced belief bias on the development of anxiety disorders. Reactions to a fear conditioning paradigm such as in Chapter 3 (Exp. 2) should be compared between groups of participants with experimentally
enhanced belief bias and experimentally reduced belief bias. As noted earlier, we would recommend to set up fear conditioning studies related to each anxiety disorder, separately. If belief bias is experimentally enhanced, delayed extinction would be expected, whereas experimentally reducing belief bias would result in relatively speeded extinction. Preferably, both enhancement of belief bias and reduction of belief bias should be compared to no manipulation of belief bias. Special attention needs to be paid to the generalisability of these retraining effects beyond the task in which belief bias was retrained (cf. Salemink, van den Hout, & Kindt, 2010), as we need to create an enhanced or reduced bias in reasoning that can be transferred to the fear conditioning task.

At present, we have only limited leads on how to sustainably manipulate belief bias. We need to gain this knowledge to be able to experimentally test the role of belief bias in the development of anxiety disorders, as well as to be able to investigate the therapeutic use of a (still to be developed) belief bias modification training. Several factors, known to influence belief bias, regrettably are difficult (if not impossible) to bring under experimental control, such as intelligence, working memory, age. Relevant factors that may be more easily influenced are cognitive load, time constraint, instruction and training. Decreasing working memory capacity by increasing cognitive load will likely result in increased belief biased reasoning, yet this does not influence the default mode by which participants engage in reasoning processing. A similar line of reasoning holds for introducing time constraints. Cognitive load and time constraints only temporarily hinder participants from engaging in more thorough System 2 processing. More promising factors for influencing belief bias are instruction and training in logical reasoning. Yet, the effects of instruction and training are small and not easy to induce (cf. Neilens, Handley, & Newstead, 2009). Factors that have not been studied in the context of belief bias, but that may prove helpful in modifying belief bias are feedback and allocation of attention. In order to create enhanced belief bias, participants can receive positive feedback (e.g., a smiling face) directly after all trials that have been answered in line with the believability of the syllogisms conclusions. This would mean that one would receive positive feedback after accepting believable-valid and believable-invalid trials and after rejecting unbelievable-valid and unbelievable-invalid trials. In order to create a reduction in belief biased reasoning, positive feedback should be related to accurate evaluation of the logical validity. In addition, when trying to induce an enhanced belief bias, a relatively high percentage of believable-valid and unbelievable-invalid syllogisms could be presented, whereas a relatively high percentage of believable-invalid and unbelievable-valid syllogisms could be presented in order to reduce belief bias. Furthermore, allocating attention to the believability- or
validity-relevant aspects of the syllogisms could potentially help people to focus their reasoning process. When trying to enhance belief bias, participants should allocate less attention to the premises and more attention to the (believability of the) conclusion. By visually drawing attention to the conclusion and reducing attention to the premises, participants can be aided in this process. In order to reduce belief bias, attention has to be drawn away from the believability of the conclusion and be focused on the logical construction of the syllogisms. In order to do this, attention needs to be directed to the premises as well as the conclusion. Through this, relative to the enhanced belief bias manipulation, this may induce a careful consideration of all pieces of information. Such carefulness may generalise to daily-life. Allocation of attention can for instance be achieved by using a prior-to-presentation fixation cross. Additional ways to manipulate belief bias should be explored. It will probably take multiple training sessions to create modified belief bias effects that can be generalised to different tasks.

The present thesis is a first step in determining the involvement of belief bias in the development and maintenance of anxiety disorders. With the aforementioned suggestions, the causal status of belief bias in the development and maintenance should become more clear. Another interesting line of research lies in the relevance of domain-specific and/or generally enhanced belief bias in the treatment of anxiety disorders. Belief bias can be hypothesised to hinder effective treatment, as it leaves patients less open minded for change. On the other hand, a domain-specific belief bias can potentially be of use to the therapist: If belief bias is an important component through which anxiogenic dysfunctional convictions are sustained, then patients with (high levels of) domain-specific belief bias should benefit substantially from cognitive therapy (in which reasoning errors are targeted). Also, it should be explored whether post-treatment belief bias can serve as a predictor for relapse. As a first step to shed light on these questions regarding relevance of belief bias for treatment, we are currently conducting a study in which SAD and PD patients are tested for domain-specific and generally enhanced belief bias as well as anxiety symptoms, prior to treatment, post-treatment and at follow-up. We expect that this study will shed light on how initial levels of belief bias relate to symptom reduction during treatment, and whether post-treatment levels of belief bias can predict symptom relapse (Vroling & de Jong, 2010, June).

Concluding remarks
The present thesis provides an indication for the involvement of generally enhanced belief bias in the development of anxiety disorders. Learning experiences are a necessary moderator for this relationship. It seems that the
role of generally enhanced belief bias in the development of anxiety disorders is relatively minor: Had belief bias been a highly important contributor, we would already have found this relationship in general samples. Also, we would likely have found more pronounced discrepancies between patients and NCCs, with patients showing more generally enhanced belief bias.

The domain-specific belief bias effect needs further testing with better matched reasoning materials. It is likely that domain-specific beliefs bias will indeed prove to exist, and will prove to be related to the strength of anxiogenic dysfunctional cognitions or to the strength of implicit anxiogenic associations. Whether domain-specific belief bias is indeed causally involved in the maintenance of anxiety disorders also needs further testing. A first step would be to observe whether domain-specific belief bias is reduced after successful treatment. A second and more crucial step would be to experimentally reduce domain-specific belief bias to see whether this leads to a reduction of anxiety symptoms.

With respect to clinical relevance, it is important to note that belief bias may affect treatment results: The study reported in Chapter 6 contains only the first part of a larger study in which patients are followed over the course of treatment. Preliminary data from this study suggest that indeed both domain-specific as well as neutral belief bias can be found to be related to treatment outcome (Vroling & de Jong, 2010, June).