Instruction and Experience Based Belief Construction and Revision

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Abstract

In this paper we discuss the difference between instruction and experience induced belief construction and its resistance to conflicting evidence. Experiment 1 is a succesful replication of the renewal effect with experience induced belief acquisition. In Experiment 2, it is shown that the level of belief acquisition that is obtained through experience is also obtained through instruction. Nevertheless, the absence of a renewal effect in this experiment shows that both learning methods differ in their underlying cognitive structure.

Keywords: reasoning, learning, belief revision

Introduction

Since Elio and Pelletier (1997) presented their seminal paper on belief revision, existing reasoning theories were challenged to adopt defeasible reasoning in their framework. While the human contingency literature was previously very behaviourally inspired, a growing recognition for cognitive processes, among which belief revision (e.g., Catena, Maldonado, & Cándido, 1998) is observed. A cross-fertilisation of both research areas seems obvious. However, a major problem for the transferability of experimental results may be that the research areas have a different method to (artificially) construct the belief that is to be revised in a later stage. In this paper, we test the similarity between instruction and experience induced belief states. But, before going on to that, we give a brief sketch of the reasoning and the contingency learning literature.

Reasoning

Research on belief revision has only very recently become a topic of interest within reasoning research. For a review of the theories and recent data in a special issue on reasoning from inconsistency, we refer to Dieussaert and Schaeken (2005).

Generally, participants are given a conditional statement (if p, then q; e.g., if that bacteria is present in your blood, then you have the Okro disease) and a categorical statement (p; e.g., the bacteria is present), and are asked to deduce the conclusion, or are given the conclusion (q; e.g., you have the Okro disease). Next, new information that contradicts the conclusion is given (not-q; e.g., you do not have the Okro disease) and participants are asked to revise one of the former statements in order to regain a consistent belief set.

Elio and Pelletier (1997; see also Elio & Pelletier, 1994) showed that the conditional premise is revised rather than the categorical premise when an inconsistency arises. Since that pioneer study, several observations regarding belief revision have been made. Interesting for this paper is the observation that the initial belief in the conditional plays an important role: The lower the initial belief in the conditional rule, the more revision of the conditional rule takes place (see Dieussaert, Schaeken, De Neys, & d'Ydewalle, 2000; Politzer & Carles, 2001; Calvillo & Revlin, 2002; Verhaert, 2004).

Since the reasoning literature has mainly focused on deductive reasoning, theoretical developments on defeasible reasoning are rather limited in the reasoning literature. We would like to mention some notable exceptions, see Johnson-Laird, Girotto and Legrenzi (2004) for a mental model based approach; .see Oaksford and Chater (1994) for a probabilistic approach; and see Revlin, Cate, and Rouss (2001) for a modal logic approach.

Human contingency learning

One of the subdomains of psychology in which particularly interesting research related to belief revision is conducted, is that of contingency learning. For a review, see De Houwer and Beckers (2002).

In most human contingency learning experiments, participants receive information about a number of situations in which certain Cues (C) and Outcomes (O) are either present or absent, and they are asked to judge the extent to which the presence of a C is related to the presence of O. On the basis of this information participants will be able to formulate a rule about the C-O relation.

In reasoning research, the learning part is restricted to the presentation of the established relationships in the form of conditional statements (If C, then O) or universal quantifiers (All C's are/have/.. O's). The similarity between the C-O relations and conditional statements (If C, then O) is obvious. Knowledge about the principles and circumstances under which C-O relations are acquired and extinguished can lead to fruitful insights in how belief states are constructed and revised and vice versa.

Two dominant classes of models have ruled research on human contingency learning for a long period: probabilistic (e.g., Cheng, 1997) and associative models (e.g., Rescorla & Wagner, 1972). Nowadays, the idea that associative *and* probabilistic processes play a role in human contingency learning gains ground (e.g., Catena, Maldonado, Megias, & Frese, 2002). Individuals are able to rely upon a probabilistic calculus when they believe that this is an adaptive way of behaving within a certain context. In the reasoning literature a similar view has been developed regarding task dependent processes (e.g., Evans & Over, 1996; Sloman, 2002; Verschueren, Schaeken, & d'Ydewalle, 2005).

Belief construction and revision

As may be clear now, both research areas use a different experimental paradigm to induce a belief in a C-O relation. These operationalisations reflect a different view on how beliefs are constructed: through instruction (if C, then O) or through experience (several C-O trials). We consider both forms of belief construction important since people construct their beliefs in various ways, depending on the situation. Some beliefs are constructed through communication (e.g., If you run out of brake oil, your brake will not work) while others are constructed through experience (e.g., If you eat, your hunger stops).

The main goal of this study is to find out whether the methodology of belief construction affects the belief strength and whether it affects the belief revision process. In other words, does a theory driven or a data driven belief construction give rise to a more entrenched belief state? As a case study, we focused on a rather recent discovery in human contingency learning, viz. the phenomenon of 'renewal' (e.g., Garcia-Gutierrez & Rosas, 2003): the return of an extinguished C-O relation due to context change. Translated in terms of the reasoning process, renewal refers to a (renewed) expression of someone's belief in the conditional sentence (if C, then O), despite the presence of contradictive information (C and not-O).

In Experiment 1, we try to replicate the renewal effect in our experimental set up. We considered this necessary given the recency of the finding in human contingency learning. In Experiment 2, we repeat Experiment 1 but with the important change that the belief is induced through instruction instead of through experience. We will also make an extensive comparison of the results of the two experiments.

Experiment 1

Method

Participants

Forty four participants took part in the experiment. Twenty first year students at the University of Leuven took part as a partial fulfilment of a course requirement and 24 high school students (age: ± 18) took part on a voluntary basis. They were randomly assigned to the different groups.

Design

The within-subjects independent variable Phase consists of three levels: belief construction, belief revision and test. A judgment is given at each trial, followed by feedback. In the belief construction phase, a C (present bacteria Verde) – O (Okro disease) relation is taught. This phase consists of 10 trials with the following course: three experience trials (C – O), one test trial (C – no information), two experience trials (C – O), one test trial (C – no information), two experience trials (C-O) and one test trial (C – no information). In the belief revision phase, participants experience that the O (Okro disease) does not follow from the C (bacteria Verde). This phase also consists of 10 trials with the same course as the belief construction phase, except that the experience trials express a C – not O contingency. In the test phase (1 test trial), the C-O relation is tested (C- no information available).

belief construction	belief revision	test
Context A (10 trials)	Context A (10 trials)	Context A (1 trial)
Context A (10 trials)	Context B (10 trials)	Context A (1 trial)

Figure 1. Course of two levels in Experiment 1.

The between-subjects independent variable is Context. The belief revision phase is set in the same (Context A) or another (Context B) context than the belief construction phase. More specifically, the hospitals from which the patient filing cards are taken is manipulated.

Material and Procedure

Participants were instructed in written form. They were asked to imagine being a researcher in a medical research institute, who collected the filing cards of a lot of patients. A computer program was developped with 'AFFECT'[1] software. It was run on standard PCs. Participants were shown jpeg-figures containing a patient filing card with the following information:

- the name of the hospital (in a particular color for each hospital)
- the result of a test on the presence of the yellow bacteria 'Amarillo'
- the result of a test on the presence of the green bacteria 'Verde'
- the result of a test on the presence of the pink bacteria 'Rosa'

If the result is positive, the bacteria are present. If the result is negative, the bacteria are absent. All figures were equal: the bacterias Amarillo and Rosa being always absent, the bacteria Verde being always present.

It is the participant's task to find out whether one of these bacteria causes a newly discovered disease, 'the Okro disease'.

The participants received several experience and test trials. They saw a filing card for 7 seconds. Within this period they were asked to mark the extent to which they believed a patient has the disease. They did so by pressing a number from 1 to 9, where 1 indicates 'certain the patient does not have the Okro disease' and 9 indicates 'certain the patient has the Okro disease'; 5 indicates 'the patient may or may not have the disease'. Once the participant had given the answer, (s)he received feedback on the condition of the patient. In the experience trials the feedback was 'The patient has the Okro disease'. In the test trials the feedback was 'No information available! It is unknown whether the patient has the Okro disease or not.'

[1] Hermans, D., Clarysse, J., Baeyens, F., & Spruyt, A. (2002). *Affect (Version 3.0)* [Computer software; retrieved from http://www.psy.kuleuven.ac.be/leerpsy/affect]. University of Leuven, Belgium.

In the belief revision phase, all participants received several experience and test trials. The context in the belief revision phase was manipulated. For half of the participants the hospital setting of the filing cards was the same (AAA level), for the other half it differed (ABA level) from the hospital setting in the belief revision phase. Only the feedback in the experience trials differed from the previous phase, it was 'The patient does not have the Okro disease'.

Halfway the experiment (after the university students were tested), an improvement was made: The filing cards were now shown until the participants had answered, since it was observed that some participants needed more than 7 seconds to form their opinion. The scale was also set to a seven point scale.

At the end of the experiment, participants of the ABA level were asked if they noticed a context change during the experiment. This question was added to make sure that only participants who actually noticed the context-change were taken into the analysis. The participant's awareness of the context change is a minimal requirement for him or her to take context into account in determining the belief state.

Participants were invited to ask questions if anything was not clear to them. During the experiment, no questions were allowed. Once participants started, they worked through the course of the experiment in a self paced manner.

Results

Due to the difference in measurement scales (see procedure) and to improve readability, a transformation of the data to a [-1; +1] scale was performed. A score of -1 indicates that one strongly believes that the the O (i.e., the disease) does not follow from the C (Bacteria Verde present). A score of 0 indicates that one is neutral regarding his/her belief on the C-O relation. A score of 1 indicates that one strongly believes that the O follows when the C is present. Since the slight changes (see procedure) did not affect the results, the data are collapsed. Two participants did not notice a context change in the ABA level; they were discarded from further analysis.

An ANOVA shows a main effect of Phase ($F(2,80) = 26.06$, $p < .0001$), and a main effect of Context ($F(1, 40) = 8.73$, $p < .01$), but no significant interaction between both.

A steadily increase in belief in the C-O relation is shown when we compare the first three experience trials: -0.40, 0.35, 0.75 (linear trend analysis: $F(1,25) = 112.64$, $p < .0001$). The belief in the C-O relation disappears, and even reverses, when participants are confronted with contradictive information (C – not O)(0.46 vs. -0.55; $F(1,40) = 50.85$, $p < .0001$). The belief increases again in the Test Phase (-0.55 vs. 0; $F(1,40) = 15.38$). However, this increase is only significant for the ABA level (-0.62 vs. -0.30; $F(1,40) = 14.82$, $p < .0005$). A planned comparison of the interaction between level and the two last phases (belief revision and test) , does not reach significance ($p = .1$).

The two contexts only differ in the Test phase (-0.30 vs. 0.30; $F(1,40) = 7.28$, $p < .05$). The change in context has resulted in a renewal effect.

Table 1. The mean score [SD] on the last test trial of the acquisition, extinction and test phase on a [-1; +1] scale.

	belief construction	belief revision	test
experience-experience AAA (N=22)	0.34 [0.71]	-0.62 [0.40]	-0.30 [0.70]
experience-experience ABA (N=20)	0.57 [0.52]	-0.48 [0.63]	0.30 [0.73]

It is important to notice that a precondition for renewal is that the acquired belief is generalized over different contexts. A comparison between the last trial of the belief construction phase and the first trial of the belief revision phase (ABA-level) shows no difference (0.57 vs. 0.35; $t(19) = 1.93$, $p = .07$). This indicates that participants do not experience a rupture between the two phases.

Discussion

In the first phase of the experiment, a belief in a predictive C-O relation was succesfully acquired through experience. Subsequently, this belief was succesfully extinguished through experience in the second trial. The extinction was conducted in the same context as the acquisition (A) or in a different context (B). A test of the belief in the C-O relation in the belief construction context (A) revealed a renewal in the belief for the ABA level, but not in the AAA level, as expected from former studies in human contingency learning.

As is commonly found in human contingency experiments, the renewal is not absolute (e.g., Vadillo, Vegas, & Matute, 2004). This does not fit completely with the theoretical model proposed by Bouton (1993). He suggests that the context change has a disambiguating influence on the predictivity of the Cue

Experiment 2

Method

Participants

Fifty two participants took part in the experiment. Twenty eight first year students at the University of Leuven took part as a partial fulfilment of a course requirement and 24 high school students (age: ± 18) took part on a voluntary basis. They were randomly assigned to the different groups.

Design

See Experiment 1. Experiment 2 differs from Experiment 1 in that the belief is constructed through instruction instead of through experience.

Material and Procedure

See Experiment 1. The belief is induced through instruction. Participants were presented a patient filing card, with the

following message underneath the card: 'if the green bacteria Verde is present, then the patient has the Okro disease'. Next, they were given a test trial.

Results

Thirteen participants did not answer the trial of the first phase (due to which the change in procedure was made). Additionally two participants did not notice a change in the ABA level and one participant did not respond on the question regarding the context change. The data of these participants were discarded from the analysis. Since the slight changes in procedure (see procedure) did not affect the results, the data are collapsed.

Table 2. The mean score [SD] on the last test trial of the acquisition, extinction and test phase on a [-1; +1] scale

	belief construction	belief revision	test
instruction-experience AAA (N=19)	0.44 [0.65]	-0.68 [0.66]	-0.43 [0.76]
instruction-experience ABA (N=17)	0.41 [0.60]	-0.53 [0.64]	-0.23 [0.67]

An ANOVA shows a main effect of Phase ($F(2,68) = 33.48$, $p < .0001$), but neither a main effect of Context nor a significant interaction between both is observed.

The belief in the C-O relation after the instruction trial is significant (0.43 vs. 0; $t(35) = 4.17$, $p < .0005$). The belief in the C-O relation disappears, and even reverses, when participants are confronted with contradictive information (C – not O)(0.43 vs. -0.60; $F(1,34) = 59.00$, $p < .0001$). The belief increases again in the Test Phase (-0.60 vs. -0.33; $F(1,34) = 5.40$, $p < .05$). However, this increase is not significant for the ABA-level (or the AAA-level) seperately.

In none of the three Phases, the Context manipulation has resulted in a difference in belief score. A comparison between the last trial of the belief construction phase and the first trial of the belief revision phase (ABA-level) shows no significant decrease due to the context change (0.33 vs. -0.02; $t(14) = 2.13$, $p = .05$). This indicates that participants do not experience a rupture between the two phases.

Discussion

In the first phase of the experiment the belief in the C-O relation was acquired through a single belief instruction. In the second phase the belief was succesfully extinguished through experience. The extinction was conducted in the same context as the acquisition (A) or in a different context (B). A test of the belief in the C-O relation in the belief construction context (A) revealed no renewal effects.

A comparison between Experiment 1 and 2: Results and Discussion

Figure 1 gives a graphic trial-by-trial overview of both experiments. Overall, Experiment 1 (Experience) and Experiment 2 (Instruction) do not differ. There is a small difference in belief score in the Test Phase (0 vs -0.33; $F(1,72) = 4.00$, $p < .05$). This is due to the difference in the ABA level: (0.30 vs -0.23; $F(1,72) = 4.77$, $p < .05$). For the AAA level, no difference could be observed. The renewal effect is only observed with learning through experience, and could not be observed with learning through instruction; Although instruction and experience seem to lead to a comparable belief strength at first sight, this is not reflected in the

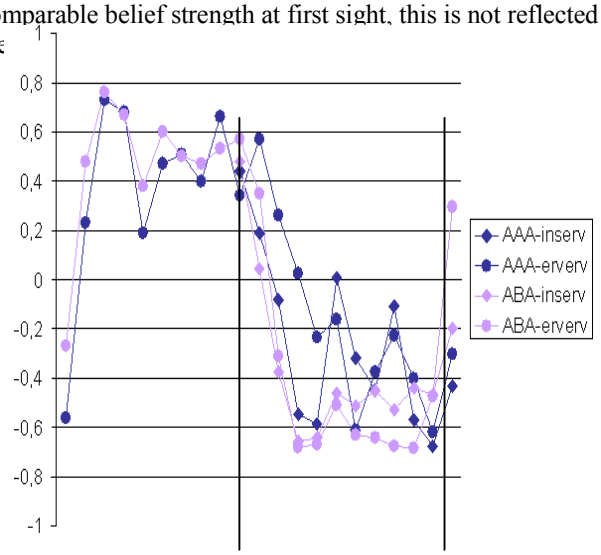

Figure 2. A trial-by-trial overview of the results of Experiments 1 and 2.

General discussion

Belief revision is a topic of interest in several areas of cognitive psychology. In this paper we discuss two of these areas: reasoning and contingency learning. In both areas artificially constructed beliefs are the topic of research. However, they both only consider one method of belief construction. In the reasoning literature a belief is constructed by instructing participants that 'If C is the case, then O is the case'. Participants learn a C-O relation by instruction. In a second phase, participants are informed that C is the case. Thus, they expect O to be the case as well. However, at that point they are told that not-O is the case, which forces them to revise their belief in the conditional statement 'if C, then O' or in the categorical information that C is the case.

In the contingency literature, a belief is constructed by presenting participants with several trials in which C is the case, and O follows. Participants learn a C-O relation by experience. In a second phase, participants are informed that C is the case. Thus, they expect O to be the case as well. However, at that point they encounter a trial (or more trials) in which C is followed by not-O, which forces them to adapt their belief in the C-O relation unless they assign the failure

of the C-O relation to occur to another factor (e.g., context change, cast doubt on the actual occurrence of C, and so on).

In this study, we manipulated the belief construction method. It was shown that participants indicate an equal belief in the C-O relation, but none of the methods is able to create a belief at full extent. Repeated exposure to contradictive information decreases the belief in the C-O relation steadily, in the instruction as well as in the experience group. However, when participants are able to assign the contradictive information to another factor, such as context, the belief in the C-O relation is less affected.

A renewal effect could only be observed with experience induced belief. It was absent with instruction induced belief. These findings can be interpreted in various ways. On the one hand, one could argue that beliefs acquired through instruction are less stable and more susceptible to negative experiences than beliefs acquired through experience. On the other hand, one could also state that instruction based beliefs are less context sensitive than experience based beliefs since no difference between the AAA and ABA level is observed. The experiments presented here are not as far reaching that they could distinguish between these two explanations. This should be sought out in further research.

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