

CONDITIONAL REASONING WITH NEGATIONS: MATCHING BIAS AND IMPLICIT VERSUS EXPLICIT AFFIRMATION OR DENIAL

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We report a study examining the effect of implicit affirmation and denial in reasoning with negative conditionals. Four conditional inference problems are constructed by an affirmation of the antecedent (Modus Ponens, MP), an affirmation of the consequent (AC), a denial of the antecedent (DA) or a denial of the consequent (Modus Tollens, MT). Depending on the presence of negations in the conditionals, these problems were set with an implicit or explicit type of referencing (i.e. affirmation or denial). Implicit affirmation and denial introduced matching bias effects: When the topic of the categorical premise (e.g., the letter B) does not match the topic of the conditional's referred clause (e.g., If there is a letter A), participants made fewer conditional inferences. The effect of implicit affirmation (e.g., 'the letter B' affirms an antecedent 'if there is no A') was larger than the effect of implicit denial, and reading times (obtained by eye movement recordings) showed that implicit affirmation problems took longer to solve whereas implicit denial problems were solved faster than the explicit denial problems. Both findings are novel and we hypothesize that the larger effect on implicit affirmation of a negative (as compared to implicit denial of an affirmative) is due to uncertainty in considering a single instance sufficient to affirm the entire contrast class of that negative.

Reasoning about sentences expressing an implication, like the conditional sentence constructed with the connective 'if_, then _', has been one of most investigated aspects in the psychology of propositional reasoning. This is nicely illustrated by the fact that in a recent review of reasoning research (Evans, Newstead, & Byrne, 1993) three chapters were devoted to conditional reasoning. Also, many psychologists investigated the understanding of negations (see, e.g., Carpenter & Just, 1975; Clark & Chase, 1972; Greene, 1970; Trabasso, Rollins, & Shaughnessy, 1971; Wason, 1965; Wason & Jones, 1963). These two research topics combined

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into investigations of conditional reasoning with negations. The present study aims to extend existing research on conditional reasoning with negations by looking further into a bias observed in this line of research.

In investigating the impact of negations on the inferences people make about conditionals mostly the negations paradigm (Oaksford & Stenning, 1992) has been applied. In the negations paradigm one introduces a negation in the antecedent or consequent of the conditionals. The four versions of a conditional within the negations paradigm are, for instance:

if A, then 2

if not-A, then 2

if A, then not-2

if not-A then not-2

Two of the main types of conditional reasoning tasks constructed with these conditionals are the Wason selection task and the conditional inference task. The findings with the selection task within the negations paradigm yielded matching bias, whereas results on the inference task did not. In the following we introduce these two types of tasks, and will explicate the phenomenon of matching bias. To anticipate the argument we will make, a failure to observe matching on the conditional inference task is not due to specific task characteristics but to differences in the way the negations paradigm has been applied (see Evans & Handley, in press, Schroyens, Schaeken, Verschueren, & d'Ydewalle, 1998). With the selection task research has mostly been conducted within the implicit negations paradigm, whereas research with the conditional inference task has mostly been conducted within the explicit negations paradigm. The difference between these two paradigms concerns the way in which one has implemented affirmation or denial of the (affirmative or negative) clauses of a conditional: implicitly or explicitly.

Matching bias in the Wason selection task. Evans and Lynch (1973) were the first to apply the negations paradigm to the selection task and to report a pattern of findings which has since been referred to as matching bias. In the selection task people are given a conditional rule in combination with four descriptions of situations which affirm or deny the antecedent or consequent of that conditional. Take for instance the following abstract rule about the letter and number which can appear on the front and back of a card:

If the letter on the front is an A, then the number on the back is a 2.

With this rule, people could be given the following four cards:

A D 4 7

These cards correspond to instances of an affirmation of the antecedent (an A is an A: The TA, True Antecedent case), an implicit denial of the antecedent (a D is not an A: a FA, False-Antecedent case), an affirmation of the consequent (a 2 is a 2: the TC, True Consequent case) and an implicit denial of the consequent (a 7 is not a 2: a FC, False Consequent case). People

are asked to select the card(s) which one needs to turn over in order to check whether the card makes the rule true or false (alternatively, to check whether it contradicts the rule). When introducing negatives into the conditionals, the affirming or denying (i.e., referential) status of the four cards obviously changes. For instance, when the rule states 'If there is not an A on the front of the card, then there is a 2 on the back of the card', the card describing the situation 'there is an A on the front of the card' denies the antecedent. Table 1 gives both a formal and exemplary representation of the selection task within the 'implicit negations paradigm'. As noted before, the negations paradigm refers to the procedure of introducing negations in the conditionals. In the implicit negations paradigm the referential status of the logical cases is expressed implicitly for half the cases: Affirmations of a negative and denials of an affirmative are implicit, whereas affirmations of an affirmative and denials of a negative are explicit.

Matching bias refers to the finding that people less frequently select a particular card when that card's referential status (affirming or denying) is set implicitly, as compared to when it is set explicitly. In terms of 'matching' this means that people make fewer selections of a card when it mismatches the topic of the antecedent or consequent, as compared to when it matches the topic of conditional clause it refers to¹. The 'topic' of a proposition refers to what a proposition is about. For instance the sentence 'there is an A on front of the card' is about the letter A (i.e., it is affirmed that the letter A is written down on the front of the card), just as the sentence 'there is not an A on the front' is about the letter A (i.e., it is denied that the letter A is written down on the front of the card).

In Table 1 we underscored the mismatching cases, that is, the cases in which a card makes implicit reference to the conditional. Since affirmations of a negative and denials of an affirmative are implicit whereas affirmations of an affirmative and denial of a negative are explicit within the implicit negations paradigm, matching bias can be specified as the following pattern of effects: a) people select the TA card less frequently when the antecedent is negative (implicit affirmation) than when it is affirmative (explicit affirmation), b) they select the TC card less frequently when the consequent

¹ The conditione sine qua non of matching bias is an inhibitory pattern of effects. People less frequently select cards when there is a mismatch between the card and the conditional it refers to. Matching bias is therefore best labelled mismatching bias. It must be noted, however, that in the matching bias literature there is some debate about whether 'matching' also has a positive effect in that a 'match' suffices for people to select a particular card (see, e.g., Evans, 1998; Evans & Over, 1996, 1997). In the present article we adhere to a conservative reading of matching bias (i.e., mismatching bias) and remain undecided regarding the potentially broader scope of matching bias.

Table 1
*Formal and Exemplary Representation of the Four-Card Selection Task
 Within the Implicit Negations Paradigm*

Conditional	Antecedent		Consequent	
	Affirmed (TA)	Denied (FA)	Affirmed (TC)	Denied (FC)
Formal				
$Pp \rightarrow q_Q$	Pp	$\underline{z}_P$	q_Q	$\underline{z}_Q$
$Pp \rightarrow \neg q_Q$	Pp	$\underline{z}_P$	$\underline{z}_Q$	q_Q
$\neg Pp \rightarrow q_Q$	$\underline{z}_P$	Pp	q_Q	$\underline{z}_Q$
$\neg Pp \rightarrow \neg q_Q$	$\underline{z}_P$	Pp	$\underline{z}_Q$	q_Q
Example				
If A, then 2	A	<u>G</u>	<u>2</u>	<u>1</u>
If A, then not-2	A	<u>P</u>	<u>4</u>	2
If not-A, then 2	<u>E</u>	A	2	<u>8</u>
If not-A, then not-2	<u>Z</u>	A	<u>5</u>	2

Note: Underscored cases denote a mismatch with the topic of the conditional clause it refers to. In the formal representation, ' $p \rightarrow q$ ' stands for 'if p then q', where ' $\neg$ ' is used to denote a negation. ' z ' is the value of the propositional variable indicated by the subscript ('P', e.g., a letter or 'Q', e.g., a number), which differs from the value 'p' or 'q' of these propositional variables. Propositions below the inferential line (—) represent the conditional inference.

is negative than when it is affirmative, c) they select the FA card less frequently when the antecedent is affirmative (implicit denial) than when the antecedent is negative (explicit denial), and (d) they select the FC card less frequently when the consequent is affirmative than when the consequent is negative. This simply means that the implicitly referring, mismatching cards are selected less frequently than the explicitly referring, that is, matching cards within the implicit negations paradigm.

Evans (1998; Evans & Lynch, 1973) proposed to account for matching bias within the frame of his heuristic-analytic dual process theory (Evans, 1984, 1989): Preconscious heuristics determine the relevance of the different problem aspects and people will only make inferences about the information that is judged relevant. As such, considering logically relevant information to be irrelevant or focussing on logically irrelevant information will induce errors and biases. With respect to matching bias, Evans argues that a matching heuristic directs focussing of attention on matching cases, whereas mismatching instances are considered irrelevant. As a consequence, the latter cards are neglected. For instance, the topic of the proposition that there is an A matches the topic of the proposition that there is no A; both propositions are about the letter A. In contrast, the topic of the proposition that there is a B does not match the topic of conversation in uttering that there is no A, hence, 'B' will be considered irrelevant and will not be selected.

Matching bias in the conditional inference task. In the preceding section we have presented the selection task and the phenomenon of mismatching bias that is observed when the task is presented within the implicit negations paradigm. The conditional inference task is an alternative task used to investigate conditional reasoning, but has yielded little evidence for matching bias. For sake of clarity we will first introduce this task. The conditional inference task requires participants to evaluate a given conclusion, to select their conclusion from a number of alternatives or to produce their own conclusion for conditional inference problems. These problems consist of a conditional premise and a categorical premise that affirms or denies the antecedent or consequent of that conditional. On the basis of these two premises, four conditional syllogisms can be devised: two affirmation problems and two denial problems. The categorical premise of a *Modus Ponens* (MP) problem affirms the antecedent, whereas the categorical premise in an *Affirmation of the Consequent* (AC) problem affirms the consequent. In a *Denial of the Antecedent* (DA) problem, the categorical premise forms a denial of the antecedent, and in a *Modus Tollens* (MT) problem the categorical premise denies the consequent (see Table 2). We refer to the antecedent in the MP and DA problems as the *referred clause*: In MP and DA problems the categorical premise refers to the state of affairs described by the antecedent, either by affirming or denying it. Analogously, for the AC and MT problems the consequent is the referred clause. The clause about which reasoners are invited to make inferences, will be labelled the *inferential clause*. For the MP and DA problems this is the consequent, and for the AC and MT problems, this is the antecedent. The type of responses, which are typically being referred to as the *conditional inferences*, are the affirmation of the inferential clause in the case of affirmation problems, and the denial of the inferential clause in the case of denial problems. That is, affirming the consequent is the conditional inference for the MP problems, affirming the antecedent is the conditional inference for the AC problems², a denial of the consequent is the conditional inference for the DA problems, and a denial of the antecedent is the

² Inferring the affirmation of the antecedent from an AC problem is not a logically valid conclusion. In formal propositional calculus the conditional 'if p, then q' is only false in the case the antecedent is true and the consequent is false (the p and ~q contingency) and it is true in all other possible combinations of the constituent propositions being either true or false: pq, ~pq, ~p~q. Hence, from an AC problem in which the consequent is affirmed, it does not follow necessarily that the antecedent must be affirmed: The conditional is also true in the case the consequent is true and the antecedent is false. Analogously, denying the consequent as a conclusion for a DA problem is not a logically valid conclusion. In general, a conditional 'if ... , then ...' is not the same as uttering the proposition 'if, and only if ..., then ...'.

conditional inference for the MT problems. Table 2 gives a summary of the conditional inference task within the explicit negations paradigm.

Given that most research on conditional reasoning with negations in the conditional inference task has been conducted within the explicit negations paradigm, it is not surprising that no mismatching bias has been observed in this task, as compared to the selection task which has mostly been presented within the implicit negations paradigm. In the explicit negations paradigm there is always an explicit reference to the conditional clause, that is, there is always a match between the topic of the card or categorical premise and the conditional clause it refers to. Mismatching bias would therefore not be expected. Most recently, Evans and Handley (in press) and Schroyens et al. (1998) independently observed that introducing implicit affirmation and denial also induces mismatching effects in the conditional inference task. These findings are in line with evidence indicating that matching bias in the selection tasks hinges on the use of the implicit negations paradigm (see Evans, Clibbens, & Rood, 1996). With the present study we aim to further investigate matching bias in the conditional inference task by applying the

Table 2
The Conditional Inference Problems (and conditional inferences) Set Up by an Affirmation or Denial of the Antecedent or Consequent Within the Explicit Negations Paradigm

Conditional	Problem type			
	Affirmation		Denial	
	MP	AC	DA	MT
<i>If p, then q</i>				
Categorical premise	p	q	not p	not q
Conditional inference	q	p	not q	not p
<i>If p, then not q</i>				
Categorical premise	p	not q	not p	q
Conditional inference	not q	p	q	not p
<i>If not p, then q</i>				
Categorical premise	not p	q	p	not q
Conditional inference	q	not p	not q	p
<i>If not p, then not q</i>				
Categorical premise	not p	not q	p	q
Conditional inference	not q	not p	q	p

Note: MP = affirmation of the antecedent, i.e., Modus Ponens; AC = affirmation of the consequent, DA = denial of the antecedent, MT = denial of the consequent, i.e., Modus Tollens.

implicit negations paradigm. More particularly, we set out to test the matching heuristic proposed to account for matching bias in the selection task.

The Experiment

The present experiment was set up to test whether matching bias can be introduced in the conditional inference task by using the implicit negations paradigm, as it is in the selection task (Evans et al, 1996). To measure matching bias, one classically computes the difference between the performance on the explicit problems and implicit problems within the implicit negations paradigm. Analogous to the representation of the selection task problems within the implicit negations paradigm, Table 3 gives a formal representation of the conditional inference problems within the implicit negations paradigm. We devised the experiment such that not only the responses, but also different latencies could be measured optimally. This was accomplished by registering the participants' eye movements while they were solving the problems. Eye movement recordings have been a useful tool in assessing the processing characteristics of cognitive tasks such as scene-perception and reading (e.g., Rayner & McConkie, 1976; Schroyens, Vitu, Brysbaert, & d'Ydewalle, *in press*). Hereby, it is assumed that there is a close link between what is fixated and what is cognitively processed. In the context of the present study, it is presupposed that a longer fixation of a sentence part is a sign of a longer mental processing of that sentence part. In a recent study by Schroyens, Schaeken, Fias & d'Ydewalle (1998,1999), the use of eye-movement recordings has indeed aided in localising processing difficulties in conditional inference problems.

With respect to the percentages of conditional responses, the expectations are quite clear. They are a simple translation of the mismatching bias effects observed on the selection task within the implicit negations paradigm. The explanation of mismatching bias effects in terms of perceived relevancy induced by the matching heuristic can equally well be applied to predict them. First, implicitly affirming the referred clause would result in fewer conditional inferences than when an explicit affirmation is applied. Consider for instance the following two MP problems:

- (1) If there is an A on the front, then there is a 2 on the back.

There is an A on the front.

- (2) If there is no A on the front, then there is a 2 on the back.

There is a D on the front.

In the latter implicit affirmation problem there is a mismatch between the topic of the categorical premise ('D') and the topic of the antecedent ('A').

As such, the two propositions would have no immediate or explicit relevance to each other and reasoners would conclude that nothing follows from the premises. They would therefore make fewer conditional inferences for the implicit affirmation problems as compared to the explicit problems.

Consider now the case of denial problems, for example, the two DA problems that can be set up with the above two conditionals:

- (3) If there is an A on the front, then there is a 2 on the back.

There is a B on the front.

- (4) If there is no A on the front, then there is a 2 on the back.

There is an A on the front.

For the denial problems (i.e., DA), the categorical premise poses an implicit denial when the referred clause is affirmative (problem 3). Again, these two clauses would have no immediate, explicit relevance to each other because the topics of the propositions mismatch. As such, making further inferences would be blocked and reasoners would more frequently respond that nothing can be concluded from the premises, that is, they would less frequently make the denial inference.

To test for the central concept of relevance, Evans (1996) devised an experiment to measure the time reasoners considered the cards in the selection task. If mismatching leads to an irrelevancy judgement, which results in halting further (analytic) inference processes, then mismatching cases should be looked at for a shorter period of time, as compared to matching cases. Evans' study was run on a PC and the participants were asked to point the mouse at the cards they were considering. The results showed that reasoners spent hardly any time considering the mismatching instances, whereas they spent considerable time on the matching cards they eventually ended up selecting. In analogy with the argumentation of Evans (1996), we expected shorter reading times on the problems constructed on the basis of an implicit denial or affirmation of their referred clause. The affirmation problems (MP and AC) with a negative referred clause would be read for a shorter period of time than their counterparts with an affirmative referred clause. For these problems, a matching heuristic would designate the implicitly affirming categorical premise as irrelevant with respect to the referred clause of the conditional, and reasoners would make no further inferences. As a result, reasoning or reading times will be shorter. Analogously, an irrelevancy judgement of the implicitly denied referred clause in the DA and MT problems would result in shorter reading times of these problems because of the quick irrelevancy judgement based on mismatching.

Although we will focus on the effect of implicit affirmation and denial, it was also expected that a negative in the inferential clause will cause reasoners to make less denial inferences. A negative inferential clause

requires the elimination of a double negation in order to produce the conditional inference whereas an affirmative inferential clause supposedly does not (see Evans, Clibbens, & Rood, 1996; but see Schroyens et al, 1998). Consider for instance, the following two MT problems:

(5) If there is an A on the front, then there is no 2 on the back.

There is a 2 on the back.

(6) If there is no A on the front, then there is no 2 on the back.

There is a 2 on the back.

In problem (6), reasoners need to negate the negative antecedent in order to come up with the conditional inference that there should be an A on the front, whereas for problem (5) reasoners need to negate an affirmative antecedent. On the basis of a similar mechanism, Schroyens et al. (1998) also expected and observed reliable effects of a negative inferential clause in the AC problems.

In sum, it is expected that a) fewer MP inferences are made when the antecedent is negative (mismatching topics, i.e., implicit affirmation) than when it is affirmative (matching topics, i.e., explicit affirmation), b) fewer AC inferences are made when the consequent is negative (mismatching topics, i.e., implicit affirmation) than when it is affirmative (matching topics, i.e., explicit denial), c) fewer DA inferences are made when the antecedent is affirmative (mismatching topic, i.e., implicit denial) than when it is negative (matching topics, i.e., explicit denial), and d) fewer MT inferences are made when the consequent is affirmative (mismatching topics, i.e., implicit denial) than when it is negative (matching topics, i.e., explicit denial). These predictions are the analogues of matching bias effects in the selection task. In line with Evans (1996), both the effect on the affirmation (MP and AC) and the denial problems (DA and MT) are expected to be associated with decreased reading times on the implicit versus explicit problems. With respect to the polarity of the inferential it is expected that a) fewer DA inferences are made when the consequent is negative than when it is affirmative, b) that fewer MT inferences are made when the antecedent is negative than when the antecedent is affirmative, and c) more AC inferences are made when the antecedent is negative than when the antecedent is affirmative.

Method

Design. The participants served as their own control within a 2 (affirmation or denial problems) x 2 (antecedent or consequent is the referred clause) x 2 (implicit or explicit type of referencing) x 2 (negative or affirmative conditional inferences) repeated measurements design. Table 3

Table 3
Formal Representation of the Conditional Inference Problems Within the Negations Paradigm, and an Implicit or Explicit Type of Referencing to the Referred Clause of the Problems

Affirmation			Denial		
Antecedent (MP)		Consequent (AC)	Antecedent (DA)		Consequent (MT)
Explicit	Implicit	Explicit	Explicit	Implicit	Explicit
<u>Affirmative conditional inference</u>					
$p_p \rightarrow q_Q$	$\neg p_p \rightarrow q_Q$	$p_p \rightarrow q_Q$	$\neg p_p \rightarrow \neg q_Q$	$\neg p_p \rightarrow \neg q_Q$	$\neg p_p \rightarrow q_Q$
p_p	z_Q	q_Q	p_p	z_Q	z_Q
q_Q	q_Q	p_p	q_Q	q_Q	p_p
<u>Negative conditional inferences</u>					
$p_p \rightarrow \neg q_Q$	$\neg p_p \rightarrow \neg q_Q$	$\neg p_p \rightarrow q_Q$	$\neg p_p \rightarrow q_Q$	$p_p \rightarrow q_Q$	$p_p \rightarrow q_Q$
p_p	z_Q	q_Q	p_p	z_Q	z_Q
$\neg q_Q$	$\neg q_Q$	$\neg p_p$	$\neg q_Q$	$\neg q_Q$	$\neg p_p$

Note: 'p_p → q_Q' stands for 'if p then q', where '→' is used to denote a negation. 'z' is the value of the propositional variable indicated by the subscript ('p', e.g., a letter or 'Q', e.g., a number), which differs from the value 'p' or 'q' of these propositional variables. Propositions below the inferential line () represent the conditional inference.

gives a formal representation of the sixteen problem types within this design (also see the materials). Each participant solved four instances of the 16 problem types in a different random order.

Materials. We constructed the four standard conditional inference problems: Modus Ponens (MP), Affirmation of the Consequent (AC), Denial of the Antecedent (DA) and Modus Tollens (MT). The negations paradigm was applied to the conditional, that is, the polarity of the antecedent (affirmative or negative) and the polarity of the consequent (affirmative or negative) was manipulated. In constructing the problems we used implicit referencing, as in the standard version of the selection task (see Table 1 and Table 3). A negative referred clause (the antecedent of MP and DA problems and the consequent of AC and MT problems) was implicitly affirmed for the affirmation problems (MP and AC). It was explicitly denied in the case of the denial problems (DA and MT). An affirmative referred clause was affirmed explicitly for the affirmation problems, whereas it was denied implicitly in case of denial problems.

The propositional content of the premises concerned the letters and numbers on the front or back of a card. For instance (translated from Dutch):

If there is a B on the front, then there is a 2 on the back.

The categorical premise for DA with this type of conditional formed an implicit denial:

There is a C on the front.

The MT problem is set by a categorical premise that implicitly denies the consequent:

There is a 7 on the back.

The affirmation problems, MP and AC, are set by the categorical premises 'There is a B on the front' or 'There is a 2 on the back', respectively. An example of a premise with a negative antecedent and consequent is:

If there is no D on the front, then there is no 5 on the back.

For this conditional, the affirmation problems were set by an implicit affirmation. For instance, the categorical premise 'There is a G on the front' implicitly affirms the antecedent of the conditional and, hence, constitutes an MP problem with the above conditional. Analogously, the categorical premise 'There is a 7 on the back' sets an AC problem by implicitly affirming that there is no 5 on the back. The categorical premise for the denial problems, MT and DA, with the above conditional constituted an explicit denial of the referred clause: 'There is a 5 on the back' and 'There is a D on the front', respectively.

Procedure. The participants were tested individually. When they arrived for the experiment, the calibration procedure and the experimental task was explained to them. A bite bar with dental impression compound was prepared and used to minimize head movements. During the calibration, the

participants fixated a series of 10 diagonally presented calibration points, which were presented one at a time in a self-paced manner.

The experimenter explained that the task was to solve inference problems based on a conditional 'If ..., then ...' sentence and a 'problem creating' sentence that says something about the letter or number on the front or back of a card. The problem was to determine what follows necessarily about the other side of the card, given that the categorical premise asserts or denies something about one side of this card. Necessity was explained to the participants in terms of possibilities. When they thought that one could have no certainty about whether a letter or number should or should not be on the other side of the card (because both the presence or absence of this letter/number could be possible), they had to choose 'no certainty' as their response. Similarly, if they didn't know what the answer was, they had to choose 'I don't know' as their response. The participants were told that although they would be timed, they should take whatever time they needed to generate the correct response.

The participants were first asked to fixate a fixation cross that appeared on the top-left side of the screen. When the eye tracker registered this fixation, the problem was presented. The second letter of the word 'als' (the Dutch equivalent for 'if') in the antecedent was transposed on to the fixation point. The consequent was presented at the same line as the antecedent. The first word of the consequent was presented at the middle of this line. The categorical premise was centred eight lines below the conditional.

The participants had to press a button when they knew which alternative they were going to select, that is, when they had found their solution. We explained that there would be four alternatives. The first two alternatives were formed by the affirmation and negation of the inferential clause and were presented respectively on the left- or right-hand side of the screen. Beneath these answer alternatives, the two other alternatives 'no certainty' and 'I don't know' were presented. Once the participants had pressed a button to indicate that they had found a solution, the problem disappeared and the answer alternatives were presented. Participants had to locate their solution among the alternatives. Software defined boundaries (invisible to the participants) were placed around the alternatives such that they were typed in bold when looked at. The participants had to press the button to indicate that the answer they were looking at was their solution. Next, the fixation point reappeared and the subsequent trial could start.

Apparatus. Eye movements were recorded by means of a generation-V dual-purkinje-image eye tracker (Crane & Steele, 1985), with a spatial accuracy of 1' of arc. Eye movements were tracked from the right eye, but vision was binocular. The eye tracker was interfaced with two IBM 486 compatible computers. The first computer recorded the eye movement data:

Horizontal and vertical eye position were sampled every millisecond. The eye position parameters were continuously sent to a second computer which controlled stimulus presentation. This computer was interfaced with the response button. The decision to display the response alternatives, as well as the decision to start the next trial, was based on a button-press. Stimuli were presented on 21" CRT, which was placed 140 cm from the participants' eyes such that 1 degree of visual angle subtended about three characters. During the response-phase, the response alternatives were highlighted when the vertical and horizontal eye position parameters fell within the range of the software defined boundaries around the response alternatives.

Participants. Thirty-six students participated in the experiment. They were either first-year psychology students who fulfilled a course requirement or were recruited as paid participants through the student job service of the University of Leuven.

Results

The analyses were conducted on the means calculated across the four instances of the problems in each of the 16 conditions. Thirty-four trials were excluded from the analyses because technical problems with registering the answers or eye movements of the participants resulted in missing data for one of the dependent variables that were to be calculated. In addition, due to a construction error in the stimuli, the affirmation of the consequent problems with a negative in the consequent were actually presented as MT problems to 20 participants. Hence, the analyses on the affirmation of the consequent problems are based on the results of 16 participants. Appendix A gives the detailed observations and analyses (simple main effects of the reading times broken down for the antecedent, consequent and the categorical premise, and the interaction effects per type of problem). The reading times measures were analysed with analyses of variance, whereas the frequency measures were analysed by the normal approximation for large samples of the non-parametric Wilcoxon T-test for paired replicates (Siegel & Castellan, 1989).

Implicit affirmation or denial of the referred clause. Figure 1 presents the percentages of conditional inferences and total reading times on the four types of problems as a function of whether the categorical premise made implicit or explicit reference to the referred clause. As Figure 1 shows, implicit affirmation (e.g. 'B' vs. 'no A') resulted in the participants making less conditional inferences, as compared to explicit affirmation (96% vs. 57%, $T = 0.0$, $N = 31$, $Z = 4.860$, $p < .0001$; and 90% vs. 36%, $T = 0.0$, $N = 16$, $Z = 3.516$, $p < .0005$, on the MP and AC problems, respectively).

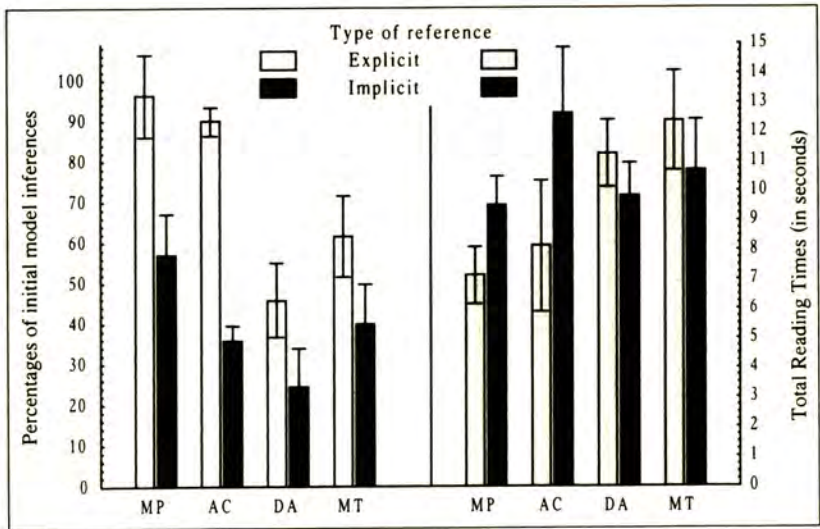


Figure 1. Mean percentages of conditional inferences and total reading times as a function of the type of problem and the type of reference.

Unexpectedly, these effects on the percentages of conditional responses were accompanied by reliably longer total reading times on the implicit affirmation problems (7.27 s vs. 9.63 s, $F(1,35) = 23.10$, $Mse = 8.860$, $p < .00005$, on MP and 8.15 s vs. 12.62 s, $F(1,15) = 24.79$, $Mse = 3.81$, $p < .0005$, on the AC problems). As can be seen in Appendix A (Table A1), the increased total reading times were not due to increased reading times of just the negative referred clause or the implicitly affirming categorical premise: Implicit affirmation increased the reading times on all parts of the problems.

The percentages of conditional inferences on the denial problems (DA and MT) also showed the expected effect of implicit reference (e.g. 'B' vs. 'A'), as compared to explicit reference (e.g. 'A' vs. 'No A'; 25% vs. 46%, $T = 34.0$, $N = 28$, $Z = 3.848$, $p < .0001$; and 40% vs. 61%, $T = 49.0$, $N = 29$, $Z = 3.643$, $p < .0005$, on the DA and MT problems, respectively). In accordance with the predictions, the total reading times on the implicit denial problems were generally shorter than on the explicit denial problems (on DA and MT, respectively, 11.75 s vs. 10.06 s, $F(1,35) = 6.26$, $Mse = 12.15$, $p < .05$, and 12.35 s vs. 10.94 s, $F(1,35) = 4.0$, $Mse = 24.01$, $p < .06$). The effect of implicit denial was not particularly more pronounced on one of the constituent problem clauses (see Table A1).

A Negative in the inferential clause. As expected, a negative inferential clause resulted in fewer conditional responses for the denial inferences than

an affirmative inferential clause: 49% versus 24% and 69% versus 37% on the DA and MT problems, respectively (see Appendix A for the relevant statistics). For both types of inferences the total reading times increased when the negative inferential clause calls for a double negation in order to come up with the affirmative conditional inference (10.40 s vs. 11.42 s and 10.40 s vs. 12.89 s, respectively). As can be seen in Table A1, the increased reading times were observed on the inferential clause itself. For the DA problems, the double negation effect was only reliable for the reading times of the consequent (3.64 vs. 4.16 s), and for the MT problems the double negation effect was most prominent on the antecedent (1.15 s) though it was reliable on all constituent reading times. On these MT problems, however, there was an interaction with the polarity of the consequent (i.e. the referred clause). The double negation effect was most strongly observed for the reading times on the problems with an affirmative consequent, that is, the MT problems with an implicitly denied referred clause (1.78 s vs. 0.56 s). This interaction was observed on the both the reading times of the antecedent and the consequent.

Unexpectedly, the MP problems also showed an overall effect of a negative in the inferential clause, that is, the consequent (80.7% vs. 73.3%). Specific comparison showed that this effect appeared only when the MP problems were implicit (i.e., in case of a negative antecedent: 64.2% vs. 50.6%). The reading times accordingly increased when the inferential clause was negative (7.89 s vs. 9.02 s). Although the percentages of conditional responses on the AC problems did not show a reliable effect of a negative in the inferential clause, the reading times were also longer on a negative antecedent than on an affirmative antecedent (9.22 s vs. 11.56 s).

Discussion

The present study established the robustness of a recent and novel finding: Implicit referencing introduces matching bias in the conditional inference task (Evans & Handley, in press; Schroyens et al., 1998). We observed that reasoners less frequently inferred the conditional responses on implicit problems than on explicit problems. In order to account for this effect of implicit referencing in the conditional inference task, we follow Evans's general framework in as far as perceived irrelevancy determines mismatching bias in the selection task (Evans, 1984, 1989, 1998). When the content of the categorical premise mismatches the content of the conditional clause it refers to, people judge the two premises irrelevant one to another and conclude that nothing follows from the premises, that is, they make fewer conditional inferences.

We applied the implicit negations paradigm to the conditional inferences task, that is, constructed the conditional inferences problems with an implicit or explicit type of referencing. However, this produces a potential confound in comparing implicit versus explicit problems. (The potentially confounding nature of negations in comparing implicit versus explicit problems, i.e., matching versus mismatching cases, is obviously also present in the selection task literature given that we simply extrapolated the implicit negations paradigm). The implicit affirmation problems are more accurately described as implicit affirmations of a negative, which are compared to explicit affirmations of an affirmative (and the other way round for the denial problems): Implicit and explicit problems are set up with different conditionals (e.g., 'if A then 2, and A' versus 'if not-A then 2, and 2'). One needs to ensure that the presence of negations, that is, the processing of negations by itself does not induce the (mismatching) effects. Recent research has shown that conditional inference problems presented within the explicit negations paradigm (see Table 2) are indeed affected by the presence of a negation in the referred clause: People make fewer affirmation inferences in case of a negative referred clause, but make more denial inferences in the case of a negative referred clause (e.g., Schroyens et al., 1998). These effects coincide with the 'matching effects', even though no implicit type of referencing is used in these studies. However, meta-analyses indicate that only the AC and DA problems are consistently affected by a negation in the referred clause (which the categorical premise affirms or denies explicitly; Schroyens & Schaeken, *in preparation*). Hence, given that MP and MT also show mismatching effects, an account which is based on the processing of negations would be incomplete. Moreover, in a recent series of studies we controlled for the potential confound in the classic 'implicit negations paradigm' and still observed reliable mismatching effects (Schroyens et al., 1998).

Our results, however, indicate that a relevancy account of mismatching effects is incomplete and that one has to make a distinction between implicit affirmation and implicit denial. A single matching heuristic which determines relevance can not account for the complete pattern of results. First, in analogy with Evans' (1996) arguments to test the notion of relevance (but see Roberts, 1998), we expected that people would generally take less time to come up with their response for implicit problems. The implicit denial problems were indeed solved faster than the explicit denial problems, but the implicit affirmation problems were solved slower than the explicit affirmation problems. Phrased as such, the reading times clearly indicate that implicit affirmation is conceptually different from implicit denial. Second, the effect size of implicit affirmation, as compared to the effect size of implicit denial indicates that coping with implicit affirmations is more

Table 4

Kendall Tau Correlations Between the Difference-Scores of Explicit Versus Implicit Affirmation in the Affirmation Problems (MP and AC) or Explicit Versus Implicit Denial in the Denial Problems (DA and MT)

	MP	AC ^a	DA	MT
MP	—	.82**	.02	.08
AC		—	.05	-.27
DA			—	.35*
MT				—

Note: * $p < .001$; ** $p < .00001$. ^a Intercorrelations between the effect size on the AC problems and the other type of problems are based on the results of 16 participants.

difficult than coping with implicit denials. Combined over the two types of affirmation problems, the effect of implicit affirmation is on average 47%, whereas the effect of implicit denial amounts to 23% on average.

Additional analyses buttress the thesis that implicit affirmation is to be distinguished from implicit denial. First, when some people seem to be able in traversing the apparent irrelevancy of mismatching cases in implicit affirmations, one might also expect them to be able to traverse implicit denials; at least if the same heuristic processes induce (ir)relevancy judgement and, hence, (mis)matching bias. Calculating the correlations between the effect size of implicit affirmation or denial in the different types of problems does not corroborate this. As can be seen in Table 4, there is no reliable correlation between the affirmation and denial problems, whereas the effect of implicit affirmation on the two affirmation problems (MP and AC) correlates reliably; as does the effect of implicit denial among the DA and MT problems. These findings again indicate that implicit affirmation is conceptually different from implicit denial. Reasoners who are able to grasp for instance that the presence of a B affirms the absence of an A, are not always capable of applying the analogous expression that a B denies the presence of an A.

Second, to further investigate the discrepancy between the implicit affirmation and denial with respect to the reading times we conducted separate items analyses on the reading times of two classes of problems. The first class of problems are those which resulted in making the conditional inferences. The second class of problems are those for which reasoners did not make the conditional inference but indicated that one can have no certainty about whether a particular letter or number should be on the other side of the card. We will refer to the latter type of inference as the 'null-inferences'. As can be seen in Figure 2, the effect of implicit affirmation was observed only on the conditional responses (MP: 7.10 s vs. 9.86 s, $F(1,48) = 6.50$, $Mse = 4.68$, $p < .05$; AC: 7.87 s vs. 12.17 s, $F(1,48) = 15.83$,

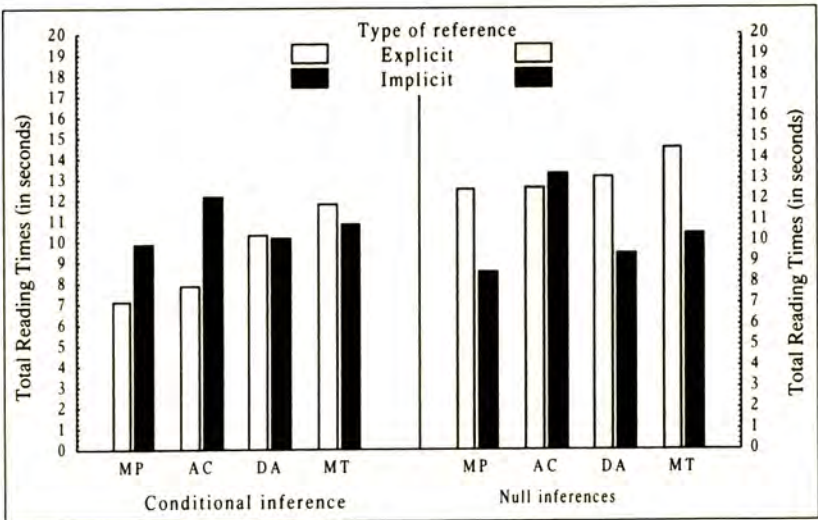


Figure 2. Total reading times on the four types of problems as a function of the type of reference and the type of inference.

$Mse = 4.68$, $p < .0005$). In contrast, the overall decrease of the total reading times on the implicit denial problems was observed on the null inferences only (DA: 13.27 s vs. 9.42 s, $F(1,41) = 8.14$, $Mse = 6.83$, $p < .01$; MT: 10.62 s vs. 13.02 s, $F(1,41) = 10.13$, $Mse = 6.83$, $p < .005$).

We think that the perception of a negative, that is, the processing of negations might contribute to the difference in the effects of implicit affirmation versus implicit denial. What do we know about the letter on the front of a card when we know that there is no A on the front of that card? Besides the fact that we know that the letter is not an A, the negation denotes the contrast class of all letters, except the letter A. If reasoners actually take into consideration that a negation delineates a contrast class, then the more difficult aspect of traversing an implicit affirmation might be that a single instance is insufficient to consider the entire contrast class affirmed. Indeed, if it is true that B is the letter on the front of a card, then it is also true that B, or C or D or ..., or Z is the letter on the front of the card. This is a logically valid argument, which people do not readily make. In contrast, the knowledge that a B is not an A is sufficient to know that the affirmation of the letter B denies the presence of the letter A, as in the case of implicit denial problems.

But how might the apparently discrepant pattern of effects on the reading times be accounted for? The faster responses to the implicit denial problems, as compared to the explicit denial problems, could indicate a quick

irrelevancy judgement on the basis of the complete mismatch between the affirmative referred clause and the affirmative, implicitly denying categorical premise (e.g. 'B' denies 'A'). To the extent that people show this matching bias, the relative proportion of quick 'irrelevancy responses' would increase, thereby shortening the combined problem solving latencies or reading times. This is confirmed by the items analyses, which showed that the overall reading time effect was most particularly due to an effect on the 'null inferences' for the denial problems (see Figure 2). In the case of an implicit affirmation problem (e.g., 'B' affirms 'not-A'), given that reasoners do consider the mismatching categorical premise and the referred clause as relevant one to another (which they do with on average 47% conditional inferences on the implicit affirmation problems), the additional processing demands induced by an attempt to traverse the more difficult aspect of an implicit affirmation (see above) would be reflected in longer latencies. The items analyses again confirm this: On the affirmation problems only the conditional inferences showed the reading time effects.

General Discussion

There were two main findings from our study. First, when conditional inference problems are set up with implicit affirmation and denial, people make less conditional inferences than when they are set up with explicit affirmation and denial. We have proposed to account for the effect of implicit affirmation and denial on the basis of the perceived relevancy of the categorical premise with respect to the referred clause. When the topic of the categorical premise does not match the topic of the referred proposition, people consider the premises irrelevant one to another and conclude that nothing can be inferred. Matching bias has previously been observed when implicit referencing is used in the abstract and indicative Wason selection task, whereas no matching bias is observed when the cards in the task form an explicit affirmation or denial of the antecedent or consequent of the conditional rule (see Evans et al., 1996; for a review see Evans, 1998).

Second, we observed that the effect of implicit affirmation is larger than the effect of implicit denial. This pattern was also clearly present in the result of Evans and Handley (in press), but was not discussed by them. The analyses on the reading times gave further evidence for the need to go beyond perceived (ir)relevancy to explain the effects of implicitness. First, the reading times of the implicit affirmation problems increased whereas we had expected them to decrease; as they did on the implicit denial problems. Second, the reading time effect on the affirmation problems was specific to the problems for which the participants generated the conditional inferences.

In contrast, the reading times effect on the denial problems was observed only on the 'nothing follows' inferences.

We have proposed that the difference in the effect size of implicit affirmation versus denial may be explained in the following way. In the case of implicit affirmation problems, the element in the categorical premise affirms a set of elements in its category, specifically the set of elements excluding the element in the referred clause. For example, given the problem 'if not-A, then 2' and 'B', B affirms the class of letters excluding A. The perception that each of these elements requires affirmation in order to draw the conditional inference leads to a reluctance to draw the inference. In contrast, in the case of implicit denial problems (e.g., 'if A, then 2' and 'B'), the element in the categorical premise (B) denies only a single element in its category, namely the element in the referred clause (A). Consequently, the conditional inference is relatively straightforward. In short, given that people consider the implicitly affirming or denying case relevant, in case of an implicit affirmation they still need to consider this single case a complete affirmation of the contrast class of the negated element in the referred clause. Reasoners would consider a case-wise affirmation of a negative to be incomplete because the affirmed case (i.e., the categorical premise) is only one element out of the many elements in the contrast class of this negative.

In sum, the present article established two phenomena in the conditional inference task. First, implicitly affirming or denying the antecedent or consequent of a conditional decreases the frequency by which people draw the conditional inference, as compared to an explicit affirmation or denial of this referred clause in the conditional. Second, the effect of implicit affirmation is larger than the effect of implicit denial. We have proposed an account for both these phenomena which is based on the perceived relevancy of the premises with respect to one another and the difficulty of constructing and affirming a contrast class of negatives.

References

- Carpenter, P. A., & Just, M. A. (1975). Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review*, 82, 45-73.
- Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology*, 3, 472-517.
- Crane, H. D., & Steele, C. M. (1985). Generation-V dual-purkinje-image eyetracker. *Applied Optics*, 24, 527-537.
- Evans, J. St. B. T. (1972). Interpretation and 'matching' bias in a reasoning task. *Quarterly Journal of Experimental Psychology*, 24, 193-99.
- Evans, J. St. B. T. (1984). Heuristic and analytic processes in reasoning. *British Journal of Psychology*, 75, 451-468.
- Evans, J. St. B. T. (1989). *Bias in human reasoning: Causes and consequences*. Hove, UK: Erlbaum.
- Evans, J. St. B. T. (1996). Deciding before you think: Relevance and reasoning in the selection task. *British Journal of Psychology*, 87, 223-240.
- Evans, J. St. B. T. (1998). Matching bias in conditional reasoning: Do we understand it after 25 years? *Thinking and Reasoning*, 4, 54-82.
- Evans, J. St. B. T., Clibbens, J., & Rood, B. (1996). The role of implicit and explicit negation in conditional reasoning bias. *Journal of Memory and Language*, 35, 392-409.
- Evans, J. St. B. T., & Handley, S. (in press). The role of negation in conditional inference. *Quarterly Journal of Experimental Psychology*.
- Evans, J. St. B. T., & Lynch, J. S. (1973). Matching bias in the selection task. *British Journal of Psychology*, 64, 391-397.
- Evans, J. St. B. T., Newstead, S. E., & Byrne, R. M. J. (1993). *Human reasoning: The psychology of deduction*. Hillsdale, NJ: Erlbaum.
- Evans, J. St. B. T., & Over, D. E. (1996). *Rationality and reasoning*. Hove, UK: Psychology Press.
- Evans, J. St. B. T., & Over, D. E. (1997). Rationality in reasoning: The problem of deductive competence. *Cahiers de Psychologie Cognitive - Current Psychology of Cognition*, 16, 3-38.
- Greene, J. M. (1970). The semantic function of negatives and passives. *British Journal of Psychology*, 61, 17-22.
- Loftus, G.R. (1993). A picture is worth a thousand p values: On the irrelevance of hypothesis testing in the microcomputer age. *Behavior Research Methods, Instruments, & Computers*, 25, 250-256.
- Loftus, G. R., & Masson, M. E. J. (1994). Using confidence intervals in within-subjects designs. *Psychonomic Bulletin & Review*, 1, 476-490.
- Oaksford, M., & Stenning, K. (1992). Reasoning with conditionals containing negated constituents. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 18, 835-854.
- Rayner, K., McConkie, G. W. (1976). What guides a reader's eye movements? *Vision Research*, 16, 618-660.
- Roberts, M. J. (1998). Inspection times and the selection task: Are they relevant? *Quarterly Journal of Experimental Psychology*, 51A, 781-810.

- Schroyens, W., & Schaeken, W. (in preparation). *Conditional reasoning: Meta-analyses and an evaluation of the mental models theory*.
- Schroyens, W., Schaeken, W., Fias, W., & d'Ydewalle, G. (1998). *Mental models, rules and biases in propositional reasoning with negatives*. Manuscript submitted for publication (Psychological Report No. 230, Leuven: University of Leuven. Laboratory of Experimental Psychology.).
- Schroyens, W., Schaeken, W., Fias, W., & d'Ydewalle, G. (1999). Is there any need for eye movement recordings during reasoning? In W. Becker, H. Deubel, & T. Mergner (Eds.). *Current oculomotor research: Physiological and psychological aspects* (pp. 279-285). New York: Kluwer Academic/Plenum Publishers.
- Schroyens, W., Schaeken, W., Verschueren, N., & d'Ydewalle, G. (1998). *Implicit affirmation and denial in conditional reasoning with negatives*. Manuscript submitted for publication.
- Schroyens, W., Vitu, F., Brysbaert, M., & d'Ydewalle, G. (in press). Eye-movement control during reading: Foveal load and parafoveal processing. *Quarterly Journal of Experimental Psychology*.
- Siegel, S., & Castellan, N. J., Jr. (1989). *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.
- Trabasso, T., Rollins, H., & Shaughnessy, E. (1971). Storage and verification stages in processing concepts. *Cognitive Psychology*, 2, 239-289.
- Wason, P. C. (1965). The contexts of plausible denial. *Journal of Verbal Learning and Verbal Behavior*, 4, 7-11.
- Wason, P. C., & Jones, S. (1963). Negatives: Denotation and connotation. *British Journal of Psychology*, 54, 299-307.

Appendix

The Appendix presents the detailed results and analyses of the reading times measures on the constituent problem clauses by depicting means with the appropriate 95% reliability ranges (Loftus & Masson, 1994; see also Loftus, 1993), which provides the same, and more, information than ANOVA's conducted on the results. With the percentages, the statistics denote the Z-value of the normal approximation for large samples of the Wilcoxon T-test for paired replicates (Siegel & Castellan, 1989). The percentages of conditional inferences, as well as total and constituent reading times of the two affirmation and denial problems are shown as a function of the type of polarity of the referred clause and the polarity of the inferential clause (affirmative or negative). The values associated with a pair of reading time means denote the reliability range of the difference between these two means in case of the reading times measures. If the difference is larger than the 95% reliability range, the effect is reliable ($\alpha = .05$). Hence, (a) the reliability range with the four types of conditionals gives the interaction between the polarity of the antecedent and the consequent, and (b) the reliability range represent with the means as a function of the polarity of the referred or inferential clause (the antecedent or consequent depending on the type of problem) denote the simple main effects per type of problem.

More specifically, the two means M_j and M_k are significantly different by a two-tailed t-test if and only if:

$$|M_j - M_k| > SE_{j,k} \cdot \text{criterion } t(df_{sac})$$

$$SE_{j,k} = \sqrt{2 \cdot MS_{sac} / n}$$

Since in the Experiment, the 95% reliability margin is determined as 2.0301 ($t_{.05}(35) = 2.0301$, $t_{.05}(15) = 2.1314$ in case of AC) times the standard error of the differences between the two repeated measurements ($SE_{j,k}$) one can easily derive the p-level that would be obtained by specific comparisons in a standard analysis of variance. First divide the given reliability margin by the criterion t-value to obtain the standard error of the differences between the two repeated measurements that are being compared ($SE_{j,k}$). Next, divide the absolute value of the overall difference (the mean of the first repeated measurement minus the mean of the second repeated measurement) by the standard error (which relates to the error term in the ANOVA's by a factor of 2). That is:

$$|M_j - M_k| / SE_{j,k} = t(df_{sac})$$

Finally, tables are commonly available to determine the p-value associated with a particular value under the t-distribution.

Table A1

Reliability Ranges of the Percentages of Conditional Responses (%) and Total and Constituent Reading Times (RT in seconds on the Antecedent 'A', Consequent 'C' and Categorical Premise 'CP'), as a Function of the Polarity of the Referred Clause and Inferential Clause (N = 36).

	Conditional					Referred clause			Inferential clause		
	pq	p~q	95%	~pq	~p~q	Aff.	95%	Neg.	Aff.	95%	Neg.
<u>Modus Ponens (MP)</u>											
%	96.5	95.8	(2.25)*	65.3	48.6	96.2	(4.86)*	56.9	80.9	(2.28)*	72.2
RT	6.60	7.68	(1.33)	9.10	9.94	7.14	(1.01)*	9.52	7.85	(.75)*	8.81
A	3.14	3.28	(.63)	4.15	4.15	3.14	(.54)*	4.15	3.57	(.32)	3.72
C	2.17	2.98	(.61)	3.14	3.52	2.57	(.38)*	3.33	2.65	(.29)*	3.25
CP	1.42	1.42	(.43)*	1.82	2.28	1.42	(.27)*	2.05	1.62	(.24)	1.85
<u>Affirmation of the Consequent (AC)(N=16)</u>											
%	84.4	35.9	(.94)	95.3	35.9	89.8	(3.52)*	35.9	60.2	(.84)	65.6
RT	7.66	10.78	(3.64)	8.66	14.47	8.15	(2.25)*	12.62	9.22	(.85)*	11.56
A	3.45	4.00	(1.83)	3.73	6.03	3.59	(.83)*	5.01	3.72	(.50)*	4.88
C	2.56	4.32	(1.42)	3.26	5.36	2.91	(.89)*	4.84	3.45	(.60)*	4.31
CP	1.64	2.45	(.73)	1.67	3.09	1.66	(.77)*	2.77	2.04	(.28)	2.38
<u>Denial of the Antecedent (DA)</u>											
%	39.6	9.7	(1.38)	55.6	36.1	24.6	(3.85)*	45.8	47.6	(3.92)*	22.9
RT	9.43	10.2	(1.75)	11.15	11.38	9.81	(1.18)*	11.26	10.29	(.82)	10.79
A	3.61	4.23	(.92)*	4.86	4.50	3.92	(.39)*	4.68	4.23	(.30)	4.37
C	3.27	3.63	(.95)	4.05	4.30	3.45	(.58)*	4.17	3.66	(.51)	3.97
CP	2.55	2.33	(.40)*	2.24	2.58	2.44	(.47)	2.41	2.40	(.24)	2.46
<u>Modus Tollens (MT)</u>											
%	56.5	74.8	(1.02)	22.9	48.1	39.7	(3.64)*	61.5	65.6	(4.30)*	35.5
RA	9.31	12.35	(2.36)*	12.15	12.44	10.73	(1.69)	12.39	10.83	(.96)*	12.3
A	4.02	5.21	(1.12)*	5.39	5.09	4.71	(.80)	5.15	4.61	(.47)*	5.24
C	3.08	4.63	(.95)*	4.27	4.54	3.68	(.70)*	4.58	3.86	(.48)*	4.41
CP	2.20	2.51	(.47)	2.49	2.81	2.35	(.42)	2.66	2.36	(.25)*	2.65

Note: See the accompanying text for the use of the reliability ranges with the reading time measures. Dependent measures are highlighted (i.e., a box is placed around them) when there is mismatching with the CP, i.e., when the affirmation or denial is implicit.

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