# Counterfactuals, indicative conditionals, and negation under uncertainty: Are there cross-cultural differences?

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#### Introduction

## Research aim:

- We aim to extend the domain of the new paradigm psychology of reasoning to investigate potential cross-cultural differences between Westerners and Easterners (Yama, in press). Specifically, we investigate...
- ... reasoning about conditionals and negation under uncertainty.

Example of an indicative conditional:

If the drawn card shows an ace, then it shows spades. (1)

Example of a counterfactual:

If the drawn card were to show an ace, then it would show spades. (2)

## **Negating conditionals:**

In general, a conditional  $A \rightarrow C$  can be negated in two ways:

narrow scope neg. 
$$A \rightarrow \neg C$$
 versus  $\neg (A \rightarrow C)$ 

## **Experimental evidence:**

Westerners' degrees of beliefs in (1) and in (2) correspond to conditional probabilities p(C|A). Negations of (1) and (2) are formed by the narrow scope interpretation (e.g., Pfeifer, 2012; Pfeifer & Tulkki, 2017).

#### **Research questions:**

- How do people interpret and negate (1) and (2)?
- Are there cross-cultural differences?

#### Method

- Participants: 63 Japanese university students
- ullet 2 (formulation) imes 2 (task order) between-participant design: indicative conditional formulation versus counterfactual formulation

Task Name (abbreviation)	Argument Form
Aristotle's thesis #1 (AT1)	it is not the case that: $(\neg A \rightarrow A)$
Aristotle's thesis #2 (AT2)	it is not the case that: $(A \rightarrow \neg A)$
Negated Reflexivity (NR)	it is not the case that: $(A \rightarrow A)$
From "Every" to "If-not" (EIn)	Every S is $P :: S \to \neg P$
From "Every" to "If" (EI)	Every S is $P : S \to P$
Modus Ponens (MP)	$A, A \rightarrow C : C$
Negated MP (NMP)	$A,A  ightarrow C$ . $\neg C$
Paradox (Prdx)	$\neg A : A \rightarrow C$

## Sample task AT1 (indicative conditional):

Hanako works in a factory that produces toy blocks. She is responsible for controlling the production. Every toy block has a shape (cylinder, cube or pyramid) and a colour (red, blue or green). For example:

- Red cylinder, red cube, red pyramid
- Blue cylinder, blue cube, ...
- Green cylinder, . . .

How sure can Hanako be that the following sentence holds?

It is not the case, that: If the toy block is not a cube, then the toy block is a cube. (もしおもちゃのブロックが立方体ではないならば、そのおもちゃのブロックは立方体である、というわけではない。)

Can Hanako infer at all <u>how sure she can be</u> that the sentence in the box holds? (please tick the appropriate box)

- □ NO, Hanako can **not** infer how sure she can be that the sentence in the box holds.
- □ YES, Hanako can infer how sure she can be that the sentence in the box holds.

If you chose "YES", please tick one of the following answers:

- □ Hanako can be sure that the sentence in the box holds.
- □ Hanako can be sure that the sentence in the box does **not** hold.

# Results

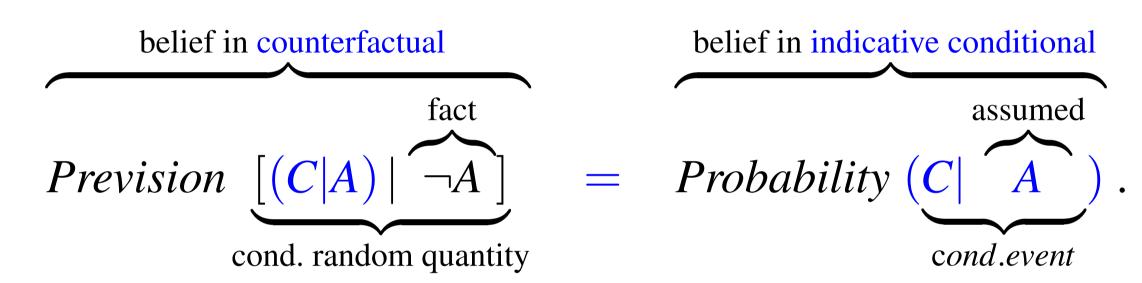
For (1) and (2) in all four groups: the majority of responses is consistent with the conditional probability interpretation of conditionals and with the narrow scope interpretation of negating conditionals (**bold**).

Responses in $\%$ $(n = 63)$	Tasks				
	AT1	AT2	NR	EIn	
holds:	<b>65.08</b> ( <sup>⊃¬</sup> / <sub>∧</sub> )	<b>76.19</b> (○¬)	6.35	6.45	
doesn't hold:	15.87	11.11	<b>63.49</b> (¬¬)	69.35	
non-informative:	19.05(¬¬)	12.70(7)	$30.16 \binom{\triangleright}{\land}$	24.20	
	EI	MP	NMP	Prdx	
holds:	88.89	53.97	9.52	$0.00(^{\circ})$	
doesn't hold:	6.35	3.17	52.38	$17.46(_{\wedge})$	
non-informative:	4.76	42.86	38.10	82.54	

- No significant differences were observed among the four groups.
- No cross-cultural differences were found.
- The experiment supports the conditional probability interpretation of conditionals.

## Discussion

- The data support the universality hypothesis of the conditional probability interpretation.
- Why is the belief in a counterfactual evaluated by the corresponding conditional probability? Formally (see, e.g. Gilio & Sanfilippo, 2013),



# **Concluding Remarks**

- Conditional probability is basic for modeling indicative and counterfactual conditionals.
- Like Westerners, most Japanese participants interpret indicative and counterfactual conditionals by conditional probabilities...
- ... and negate conditionals  $(A \to C)$  by the narrow scope negation  $(A \to \neg C)$ .

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