METU WORKSHOP ON CONDITIONAL AND CAUSAL REASONING (METU-WCCR)

March 22 - 23, 2023
Gökova, Muğla - Türkiye

ODTÜ
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dilbilim derneği

METU Workshop on Conditional and Causal Reasoning Schedule

22 March 2023, Wednesday			
Time in Ankara (TRT) (GMT+3)	**Time in New York (EST) (GMT-4)**	**Event**	
13.00 – 13.15	06.00 – 06.15	Registration	
13.15 – 13.30	06.15 – 06.30	Opening Speech	
13.30 – 14.30	06.30 – 07.30	Invited Speaker	Daniel Lassiter School of Philosophy, Psychology and Language Sciences, University of Edinburgh *Communicating with conditionals*
14.30 – 15.00	07.30 – 08.00	Coffee Break	
15.00 – 15.30	08.00 – 08.30	Session 1	Ceyhan Temürcü Graduate School of Informatics, Department of Cognitive Science, Middle East Technical University *Disentangling conditionality from implication*
15.30 – 16.00	08.30 – 09.00		Bergül Soykan Department of Linguistics and Philosophy, Massachusetts Institute of Technology *The interaction between past and conditional morphemes in Turkish*
16.00 – 16.30	09.00 – 09.30	Session 2	Duygu Özge[1], Ebru Evcen[2] [1]Language and Cognitive Development Laboratory, Middle East Technical University [2]Linguistics Department, University of California San Diego *Pragmatic context shifts the interpretation of 'unless'*
16.30 – 17.00	09.30 – 10.00		Ecenur Çağırıcı Language and Cognitive Development Laboratory, Middle East Technical University *The processing of conditional presuppositions*
17.00 – 17.30	10.00 – 10.30	Coffee Break	
17.30 – 18.30	10.30 – 11.30	Invited Speaker	Sabine Iatridou Department of Linguistics and Philosophy, Massachusetts Institute of Technology *If wishes were horses: what do wish ascriptions have to do with conditionals?*
19.00	12.00	Workshop Dinner	

METU Workshop on Conditional and Causal Reasoning Schedule

23 March 2023, Thursday			
Time in Ankara (TRT) (GMT+3)	**Time in New York (EST) (GMT-4)**	**Event**	
10.00 – 11.00	03.00 – 04.00	Invited Speaker	Stefan Kaufmann Department of Linguistics, University of Connecticut *Sculpting suppositions*
11.00 – 11.30	04.00 – 04.30	Session 3	Barbaros Yet[1], William Marsh[2] [1]Graduate School of Informatics, Department of Cognitive Science, Middle East Technical University [2]School of Electronic Engineering and Computer Science, Queen Mary University of London *Systematic simplification of causal Bayesian Networks for explanation*
11.30 – 12.00	04.30 – 05.00		Erhan Pisirir[1], Evangelia Kyrimi[1], Jared M. Wohlgemut[2], Rebecca S. Stoner[2], Zane B. Perkins[2], Nigel R. M. Tai[2], William Marsh[1] [1]Digital Environment Research Institute, Queen Mary University of London [2]Centre for Trauma Sciences, Queen Mary University of London *Causal modelling and explanation using Bayesian Networks*
12.00 – 13.30	05.00 – 06.30	Lunch	
13.30 – 14.00	06.30 – 07.00	Session 4	Robert Bowers Department of Psychology, Bilkent University *Causal reasoning and conditional relevance relations in rats*
14.00 – 14.30	07.00 – 07.30		Özge Günay Language and Cognitive Development Laboratory, Middle East Technical University *Preschool children incrementally interpret causal and concessive connectives*
14.30 – 15.00	07.30 – 08.00		Semih Can Aktepe Language and Cognitive Development Laboratory, Middle East Technical University *Children can interpret counterfactual conditionals incrementally using morpho-syntactic cues*
15.00 – 16.00	08.00 – 09.00	Coffee Break & Informal Meetings	
16.00 – 17.00	09.00 – 10.00	Invited Speaker	Magdalena Kaufmann Department of Linguistics, University of Connecticut *Complex events in conditional conjunctions*
17.00 – 17.15	10.00 – 10.15	Closing Remarks	
17.30 – 18.00	10.30 – 11.00	Azmak River Boat Tour	

Contents

Our Workshop

Conditional and causal structures are a central aspect of human reasoning and language, and have been extensively studied in fields such as linguistics, psychology, and philosophy. However, there is still much to be learned about the semantics of conditionals as well as the development and processing of conditional structures in children.

We aim to bring together researchers working on the semantics of conditional and causal structures as well as their processing by children and adult populations. This workshop will cover a wide range of studies from disciplines, including but not limited to linguistics, psychology, philosophy, and education. Potential topics may include:

- Semantics of conditionals and causal discourse markers,
- Experimental studies of conditional and causal reasoning in children and adults,
- The neural basis of conditional and causal reasoning,
- The role of conditionals and causality in reasoning, decision making, and problem-solving,
- The relationship between conditionals, causality, logic, and other aspects of cognition,
- Cross-linguistic variation in the expression and interpretation of conditionals,

We hope you enjoy the workshop.

Organising committee

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Abstracts of keynote presentations

Communicating with conditionals

Daniel Lassiter

School of Philosophy, Psychology and Language Sciences, University of Edinburgh

I will present a model of pragmatic communication with conditionals that uses RSA to infer rich, context-sensitive and causally aware interpretations from a simple conditional semantics that does not encode any information about causality. This approach can be used to explain a number of phenomena around conditional meaning and use, including the tendency to interpret conditionals as conveying causal information, the inference of relevance between antecedent and consequent, and conditional perfection. I will then show how it handles a set of puzzles from Douven 2012 which seem on face to threaten the viability of a Bayesian approach to learning from conditionals. (This talk is based on joint work with Britta Grusdt and Michael Franke: https://doi.org/10.3765/sp.15.13)

If wishes were horses: what do wish ascriptions have to do with conditionals?

Sabine Iatridou

Department of Linguistics and Philosophy, Massachusetts Institute of Technology

TBA

Sculpting suppositions

Stefan Kaufmann
Department of Linguistics, University of Connecticut

Conditional constructions create special environments for the interpretation of their constituents. The semantic contribution of temporal, aspectual, and modal expressions in conditionals can differ in puzzling ways from their "ordinary" meaning in simple matrix clauses. Formal semanticists did not pay much attention to this phenomenon until around the turn of the millennium, but by now, we have a good understanding of some basic patterns and the beginnings of a cross-linguistic perspective. However, there is still much debate on how these expressions take on their special meanings in conditionals, and how (or indeed whether) those special meanings are related to the meanings they have outside of conditionals. An additional question from a cross-linguistic perspective is whether these processes are invariant, thus presumably reflecting extra-linguistic cognitive tendencies or disparate, language-specific results of accidental conventionalization. In this talk, I will present a framework for addressing these questions, developed for English if-sentences and tested against a range of other languages and constructions. Its three main ingredients are (i) a *forward expansion* of the modal base in all conditionals; (ii) an *intervention* in all subjunctives; and (iii) a *backward shift* in PP subjunctives.

Complex events in conditional conjunctions

Magdalena Kaufmann
Department of Linguistics, University of Connecticut

In many languages, sentential conjunctions can express hypothetical conditionals ("You sing another song and I am out of here" can be read roughly like "If you sing another song, then I'm out of here"). While these come in several different forms regarding the first conjunct (plain declaratives, imperatives clauses, declaratives with sufficiency modals, and even noun phrases), the resulting conditionals always tend to express a causal or quasi-causal relation. The correct account for this restriction as well as for the process itself by which conjunctions are mapped to conditional meanings are still being debated in the literature. In this talk, I show first that epistemic conditional readings can become available in specific discourse settings. I then proceed to argue that conditional conjuncts are derived by topicalization of material from the first conjunct (building on joint work with John Whitman). As a form of asymmetric extraction, we would thus expect the topicalization operation to violate the coordinate structure constraint, and causal connections between first and second conjunct (also non-conditional in nature) have indeed been identified as cases in which extraction from just one conjunct is acceptable. In the remainder of the talk, I will try to extend Truswell's analysis in terms of complex event formation (Truswell 2011, Iliadis 2021) from the typical causal readings of conditional conjunctions to the puzzling epistemic cases.

Abstracts of presentations

Disentangling conditionality from implication

Ceyhan Temürcü

Graduate School of Informatics, Department of Cognitive Science, Middle East Technical University

The term *implication* in logic denotes a relation or operation which links one or more premises to a conclusion. In analyses of natural language implication has been conceived and interpreted in many different ways, under different terms including material, strict, and default implication. Despite various controversies, nearly all treatments of implication in natural language follow propositional logics in conflating implication and conditionality, by representing implication as a conditional statement.

In this talk I will argue that implication (and its interpretative counterpart, *inference*) should be disentangled from conditionality. In particular, I will show that (a) a conditional utterance does not necessarily express an implication or inference, and that (b) implication is not necessarily expressed with a conditional statement. Below are some examples for the first point (a) above.(1) expresses an implication with a conditional *if ... then* construction, but in (2) *then* expresses this relation without an *if*-clause. Similarly, the discourse marker *so* in (3) and the evidential adverb *apparently* in (4) signal non-conditional implications:

(1) If a scholar authenticated a work as by a major artist, then its price was certain to be higher. (A04 940)
(2) In several ways, then, a catalogue may be in advance of any other publications. (BNCweb: A04 998)
(3) 'So Arthur's a doctor ... ' divined Henry without too much difficulty. (BNCweb: A0D 2550)
(4) Apparently, the abbey had suffered from the loss of seasonal pasture.(Cambridge English Corpus)

The second point (b) can be exemplified within the following corpus examples. Both (5) and (6) are conditional constructions, yet it is difficult to say that they express any implication in the sense of a logical consequence. The apodosis of (5) is in the imperative mood, hence is prescriptive rather than being descriptive. And the apodoses of (6) and (7), although assertive in form, expresses an advice and an intention respectively, rather than implications or inferences:

(5) If you have a question about acting, think about it before you ask it. (BNCweb: A06 1411)
(6) If this unlikely situation arises, you should discuss the problem with us. (BNCweb: A01 304)
(7) And if his name be George, I'll call him Peter. (BNCweb: A06 434)

I will present my analyses in a dynamic semantic framework which incorporates a *judgmental logic*, i.e., one which takes implication as a relation among judgments rather than propositions. I will analyze conditional utterances as adding information into non-actual worlds (epistemic contexts) via assertive or non-assertive apodoses. This addition is no different from discursively adding information to the current epistemic context: In both cases there may or may not be reference to an implicational relation. Yet, in both cases the speaker will normally want to remain rational to avoid contradiction or inconsistency with what is already taken as granted at the local context. Consistency can always be checked by the addressees in the interpretative processes of merging and updating the DRS or the common ground.

The interaction between past and conditional morphemes in Turkish

Bergül Soykan

Department of Linguistics and Philosophy, Massachusetts Institute of Technology

Turkish has two conditional morphemes, namely *-sA* and *-ysA*, which differ in their morphosyntax and semantics (Göksel & Kerslake, 2005). The *-ysA* marker attaches to inflected verbs and nominal predicates to generate what von Fintel and Iatridou (2022) call O-marked conditionals (O.COND). In contrast, the *-sA* morpheme only attaches to bare verb roots and creates a counterfactual interpretation as in X-marked conditionals (X.COND) proposed by von Fintel and Iatridou (2022). The past morpheme (PAST) can surface either before the O.COND (-ysA) and denote its conventional time information, or after the X.COND (*-sA*) and generate a counterfactual reading. It needs to be noted that, the non-past version of X.COND, is licensed in cases where the speaker believes the antecedent event to be possible but unlikely. My aim is to provide an explanation for these three different meanings by comparing the PAST in O.COND with X.COND and past and non-past versions of X.COND.

While the PAST in the antecedent of O.COND does not affect the time of its consequent clause, the one in the antecedent of X.COND requires the use of the PAST in the consequent. However, it is not necessary to have the PAST in the antecedent of X.COND to have a *counterfactual* interpretation; having it in the consequent would suffice without any meaning difference. Analogous to English, X.COND requires the use of a modal operator, mostly the aorist in the consequent while O.COND does not impose such a restriction. Moreover, the PAST with O.COND only licenses past-time adverbials, unlike the PAST in X.COND which allows using both past and non-past adverbials.

Although both past and non-past X.COND are felicitous in counterfactual contexts where the antecedent proposition does not hold at the utterance time, they differ in their presuppositions, especially in terms of presupposing the existence of the referents in the antecedent at the utterance time (Ippolito, 2002). For instance, in a context where the subject of the antecedent is dead at the utterance time, only the X.COND with the PAST would be felicitous not the non-past version. Notice that only X.COND with the PAST is compatible with epistemically impossible scenarios while the one without the PAST is felicitous with epistemically possible but unlikely events in Turkish. Additionally, while X.COND can scope over the perfective morpheme *-mIş*, it cannot scope over the PAST. Therefore, it seems like the PAST cannot add its time interpretation directly to the antecedent clause and is interpreted above the modal of X.COND.

In this study, I argue that the PAST in O.COND is interpreted as the evaluation time of either the antecedent proposition or the consequent prejacent of the conditional modal based on where it surfaces. However, the one with X.COND adds another level to X-marking by scoping over it and widens the domain of the modal so that it contains impossible/remote worlds. I agree with Kaufmann (2022) that X-marking can be split into two dimensions, but I stay agnostic about if the dimension that the PAST adds is temporal or modal in X.COND in Turkish.

References:

Göksel & Kerslake (2004) *Turkish: A comprehensive grammar.*
Ippolito (2002) *The time of possibilities: Truth and felicity of subjunctive conditionals.*
Kaufmann (2022) *How to be impossible or remote.*
von Fintel & Iatridou (2022) *Prolegomena to a theory of X-marking.*

Pragmatic context shifts the interpretation of 'unless'

Duygu Sarısoy [1], Ebru Evcen[2]

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Although conditional thinking is an integral part of human cognition, the type of inferences derived from conditional statements.For instance, whether a conditional connective receives *uni-conditional* or *biconditional* meaning is far from clear.[1, 2, 3, 4, 5] A connective is uni-conditional when a statement like *if p, then q* is treated as false only if the antecedent p is false while the consequent q is true while it is treated as true in all other cases. Biconditional interpretation, on the other hand, requires that both the antecedent p and the consequent q are true to be treated as true, otherwise, it is false.

We know from the psychology of conditional reasoning that speakers do accept fallacious conditional statements by interpreting the uni-conditional as a biconditional (i.e., *Affirming the Consequent*; assuming that the antecedent must always be true when the consequent is true).[6] A similar pattern is observed for the exceptive conditional *unless* when it leads to a uni-conditional interpretation, which is dubbed as a mechanism of *conditional perfection*.[7] Indeed, there is no settled analysis of what exactly *unless* means. The classical approaches took it as *if not*[5], some recognized that the structure in which the conditional statement with *unless*s is embedded may change its interpretation (e.g., positive vs. negative quantifier contexts) [3, 4] while some assigned it a strictly biconditional meaning by equating it with *if and only if not, except if*, [2] or *except for*.[1] Studies suggested that there is a similar conditional perfection mechanism for *unless* that is observed for *if*.[8] It is argued that uniqueness, just like *conditional perfection*, may actually be a generalized conversational implicature that is always at work unless it is overtly canceled. Thus, for *unless*, biconditionality is a default interpretation that arises via a pragmatic inference but it is flexibly defeasible as observed in other generalized conversational implicatures. This view also underlines that assuming a binary truth conditional content would not reflect the patterns of interpretation for the conditional structures; instead, they suggest a pragmatic mechanism entertaining multiple possibilities (e.g., both uni-conditional and biconditional interpretation for *unless*) in line with context.

This study explores the effect of pragmatic context on the interpretation of *unless*. Previous studies on English show that *if*, a uni-conditional connective, can be interpreted biconditionally in inducement contexts (promises/threats).[9] We tested whether a similar contextual effect exists for *unless*, a connective logically modeled as biconditional. We employed an acceptability rating task based on Evans et al. (2008) to test how English *unless* is interpreted in rule vs. advice contexts (Table 1).

157 participants saw an utterance with *unless* followed by an inference either requiring or not-requiring a biconditional reading and rated the likelihood of each inference on a 7-point scale. We ran mixed-effects logistic regressions to predict Z-score transformed acceptability ratings from Inference Type (MP, MT, AC, DA), Conditional (unless, if…not), and Context (advice, rule, warning). There was a main effect of Context ($X^2(1) = 12.14$, $p < .001$), such that there was a significantly higher acceptance rate in Rule and Warning contexts compared to Advice context (β= 0.37, SE = 0.09, t = 3.95, $p < .001$). Post-hoc analyses also revealed that there was a significant difference in ratings between Rule and Warning (Rule > Warning > Advice) (β= -0.32, SE = 0.09, t = -3.32, $p < .01$).

Thus, the interpretation of unless (like *if* [9]) changes with the pragmatic setting, which is a novel finding supporting the claim that the meaning/interpretation of these connectives are shaped and enriched through pragmatic processes. Overall, our findings clearly contradict with the logic-based exceptive accounts of *unless* while concurring with recent studies showing that biconditionality arises as a result of pragmatic requirements.[8, 9]

Table 1: Sample test items.

(1) Advice	You are a freshman at a top university, but you are disorganized, and you have a hard time getting any work done. Your friend suggests: "You will become unsuccessful unless you work on your time management skills."
(2) Warning	You have a stomachache that has been bothering you for some time, and you go and see your doctor about it. Your doctor warns you: "You will have serious health issues unless you stop eating fast food."
(3) Rule	You are travelling abroad during the pandemic. You are at a passport control point. The officer says: "You won't be able to travel internationally unless you have a negative test result."
Inferences	MP (Modus Ponens): Given that [p], how likely is it that [q]? MT (Modus Tollens): Given that [not-q], how likely is it that [not-p]? AC (Affirming the Consequent): Given that [q], how likely is it that [p]? DA (Denying the Antecedent): Given that [not-q], how likely is it that [not-p]?

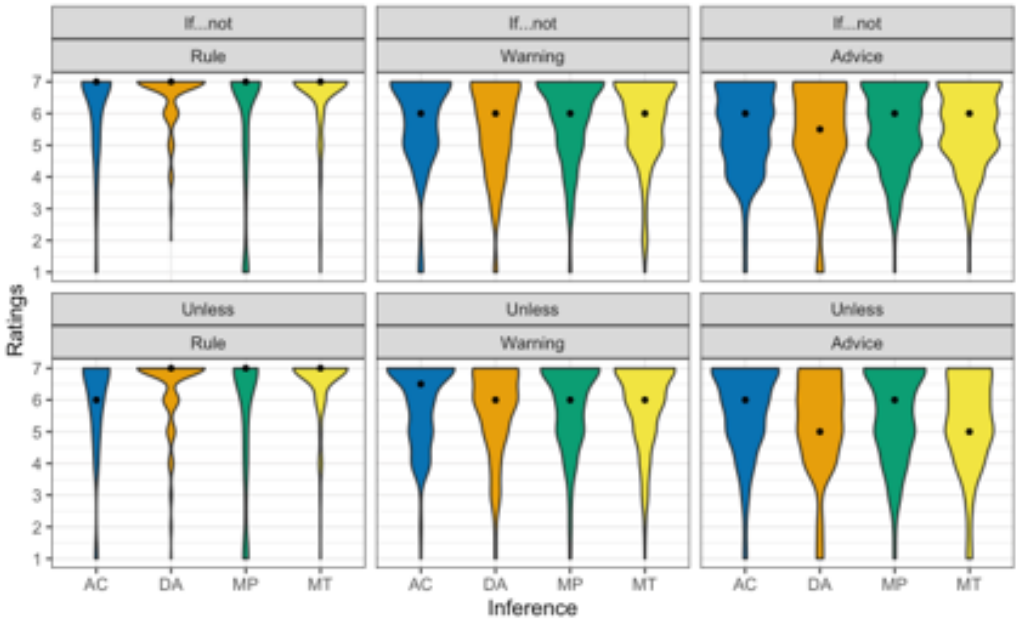


Figure: Distribution of acceptability ratings across Conditional and Context Type. The plot displays the density of the data using a mirrored kernel density plot, with the width of the plot indicating the frequency of the data at that point. The black dot represents the median value for each group.

References:

[1] von Fintel 1991; [2] Geis and Zwicky 1971; [3] Higginbotham, 1986; [4] Leslie 2009; [5] Quine 1982; [6] Evans 1993; [7] Geis and Zwicky,1971; [8] Nadathur and Lassiter, 2015; [9] Evans, Neilens, Handly and Over (2008).

The processing of conditional presuppositions

Ecenur Çağırıcı

Language and Cognitive Development Laboratory, Middle East Technical University

Conditional presuppositions arise when a presupposition embedded in the consequent of a conditional sentence projects contingent on the truth of the antecedent of the conditional. In (1), for instance, whether John has a surfboard depends on if he is a surfer. Traditional accounts have explained how conditional presuppositions may arise in mainly two different procedures, either by producing the conditional presupposition first (Gazdar, 1979; Geurts, 1999) or producing the non-conditional presupposition first (Beaver, 2001; Heim, 1988). Then, pragmatic considerations determine whether a conditional or a non-conditional presupposition projects (van Rooij, 2007). However, a probabilistic procedure is also possible in determining the final presupposition in which case the prior beliefs probabilistically determine the projection of presuppositions embedded in conditional structures (Lassiter, 2012). Previous experimental research has not considered such an option. This study aims to explore how prior beliefs influence the projection of conditional presuppositions with possessive pronouns as their triggers.

We conducted two rating studies with three types of situations that would make the conditional operator correspond to Karttunen's (1973) *filters* (entailing situations), as in (1), and *holes* (related and unrelated situations), as in (2) and (3) respectively, allowing us to vary the relationship between the antecedent and the embedded presupposition. The truth of an entailing situation makes the possession of a certain object highly likely (e.g., a surfer owning a surfboard), the truth of a related situation makes it moderately likely (e.g., an adventurous person owning a surfboard), and the truth of an unrelated situation does not affect whether someone possesses that object (e.g., someone who likes coffee owning a surfboard).

In Study 1, to obtain individuals' prior beliefs, we asked participants to rate the probability of someone in a certain situation owning an object, as in (4). The obtained data were analyzed with a linear-mixed model, which showed that prior beliefs about owning an object varied depending on the relationship between the situation and the object (Table 1). Specifically, the falsity of entailing situations significantly lowered the probability of owning the object compared to the falsity of unrelated situations. The ratings for the related situations, on the other hand, did not differ from the ratings for the entailing situations or the unrelated situations, suggesting a gradual influence of prior beliefs.

In Study 2, we adapted the scenarios from Study 1 into conditional sentences in dialogues, as in (5), to test the projection of conditional presuppositions. The results showed a similar gradual pattern of probabilities for the projection of the presupposition when the antecedent was denied (Figure 1). This finding supports that prior beliefs play a crucial role in the projection of conditional presuppositions. Additionally, when the non-conditional presupposition was denied, only entailing antecedents received a very low score, so participants accommodated a conditional presupposition only in conditionals with high probability antecedents (Figure 2).

Overall, our findings show that prior beliefs influence how presuppositions embedded in conditional structures are processed. Only entailing situations lead to conditional presuppositions. This is in line with probabilistic approaches (Lassiter, 2012).

Examples

(1) If John is a surfer, his surfboard is sturdy.
(2) If John is adventurous, his surfboard is sturdy.
(3) If John likes coffee, his surfboard is sturdy.

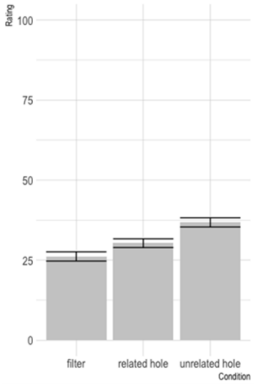
Sample Test Items

(4) Bir sörfçünün sörf tahtasına sahip olma olasılığı nedir?
'What is the probability of a surfer owning a surfboard?'
(5) Berrak: Lale sörfçüyse, sörf tahtası sağlamdır.
'Berrak: If Lale is a surfer, her surfboard is sturdy.'
Tuğba: Lale sörfçü değil. /Lale'nin sörf tahtası yok.
'Tuğba: Lale is not a surfer. / Lale does not own a surfboard.'
Lale'nin sörf tahtasına sahip olma olasılığı nedir? / Lale'nin sörfçü olma olasılığı nedir?
'What is the probability of Lale owning a surfboard? / What is the probability of Lale being a surfer?'

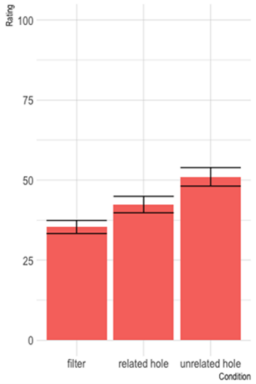
Table 1: Pairwise comparisons of ratings for the probability of owning an object.

Study 1						Study 2					
situation.positivity	Estimate	SE	df	t.ratio	p.value	situation	Estimate	SE	df	t.ratio	p.value
ent.neg - rel.neg	4.3231	3.21	187	1.348	*ns*	ent - rel	7.003	7.9	44.0	0.886	*ns*
ent.neg - unrel.neg	10.8623	3.21	187	3.386	<.05 *	ent - unrel	15.664	7.9	44.0	1.983	p=0.0536
rel.neg - unrel.neg	6.5392	3.21	187	2.038	*ns*	rel - unrel	8.662	8.2	44.0	1.061	*ns*

(a) **Figure 1:** Mean ratings for questions about owning an object when the situation is negative or denied. Error bars indicate the standard error of the mean.

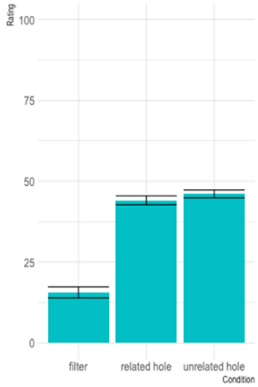


Ratings from Study 1



Ratings from Study 2

(b) **Figure 2:** Mean ratings for the probability of the antecedent after the presupposition was denied in Study 2. Error bars indicate the standard error of the mean.



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Systematic simplification of causal bayesian networks for explanation

Barbaros Yet[1], William Marsh[2]

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Causal relations in the nature are complex. A domain expert, who understands this complexity, often needs to hide a large part of this information and focus only on the essential part given the context. For example, the pathophysiology of a disease is important for a physician's causal understanding, but the physician may leave this information out when explaining the course of a patient's disease as it may be irrelevant and unnecessarily complicated for the patient. Similarly, a scientist needs to focus only on the most essential part of their causal model, considering the data that is feasible and ethical to collect, and leave less important details out. This simplification is similar to choosing the right scaled map for a task. Using a hiking map for intercity travel will be extremely challenging even though it contains more information. However, unlike setting the scale of maps, simplifying a causal model is often done informally without any systematic approach. This talk will present algorithmic approaches for simplifying causal models for a desired level of detail. Directed Acyclic Graphs (DAGs) and causal Bayesian Networks plays an essential part in causality theory (Pearl, 2009). We focus on causal models represented as DAGs. Building on Yet and Marsh (2014), we present graph operations for removing and merging observed and unobserved nodes in causal DAGs. We examine the causal and associational implications of these operations.

References:

Pearl, J. (2009). Causality, 2nd Edition, Cambridge University Press Yet, B., & Marsh, D. W. R. (2014). Compatible and incompatible abstractions in Bayesian networks. Knowledge-Based Systems, 62, 84-97.

Causal modelling and explanation using Bayesian networks

Erhan Pisirir[1,2], Evangelia Kyrimi[1,2], Jared M. Wohlgemut[3,4], Rebecca S. Stoner[3,4], Zane B. Perkins[3,4], Nigel R. M. Tai[3,4,5], D. William R. Marsh[1,2]

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We have developed a suite of prediction models intended to be incorporated into clinical decision support systems (CDSS) (for example, see [1]). Our aim is that these CDSSs can be used by clinicians to help make critical decisions faster, earlier, and more accurately. However, a clinician is unlikely to use such a system if they do not trust it[2]. To achieve trust in a CDSS, we aim to increase its transparency by giving the CDSS a capability to explain itself and its predictions. Once these explanations are generated, presenting them in clear, concise, and easy to understand natural language is an important step towards increased user trust[3].

Our prediction models are implemented using Bayesian networks (BNs). Compared to some other forms of statistical modelling, a BN has an explicit representation of the relationships between variables. We use this to capture essential causal relationships: medical evidence for these causal relationships can then support the structure of the prediction model. We extracted statements about risk factor and measurement fragments in the model to be presented in the end user's interface. This is a form of explanation of the model; we also need to explain the predictions for each case, giving an explanation of the reasoning [4].

We developed an algorithm to generate an explanation of the reasoning leading to a prediction and present it in a natural language. The first haft of our algorithm[5] takes the set of observations for each case and runs repeated probabilistic inference on the BN to detect the effect of each observation on the prediction and categorises the observations with the direction and magnitude of their effect on the outcome. This generates the abstract content of the explanation of reasoning. The second half of the algorithm uses a phrase schema and sentence template to present the abstract content as an explanation in a natural language.

This talk is a summary of our explanation work covering three streams of work. First, we have tested our explanation generation environment on models with different causal structures such as hierarchical layers, risk factors with uncertainty, and causal factors which explain away each other. Second, we ran expert explanation elicitation sessions and compared algorithmic explanations with expert ones. Although the two are easy to distinguish, we used a thematic analysis of the expert explanations to create a template for the algorithmic explanations. Third, we conducted a usability evaluation study of our CDSS to analyse the effect of the natural language explanation on users' trust in the system. We present the preliminary results of the usability study on the clarity, usefulness, ease of understandability, and trustworthiness of algorithmic explanations.

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Causal reasoning and conditional relevance relations in rats

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Rats are adept at learning relevance relations. However, it is still debated whether non-human animals of any kind represent what they learn in a way that warrants reference to causal reasoning. Whereas older, mainstream views of learning focus on modelling the strength of a correlation irrespective of its structure, causal reasoning models, such as those taking inspiration from Bayesian Networks, represent conditional independence and direct dependence dissimilarly, and anticipate the discounting of competing causes. Do rats represent conditional independence? Do rats discount competing causes? I present two studies designed to address these two questions.

Study 1 (Bowers & Timberlake, 2017) presented two groups of rats with a serial compound conditioning procedure, in which a conditioned stimulus (CS1) imperfectly (50%) predicted food and was itself imperfectly predicted by a CS2. Groups differed in the proportion of CS2 presentations that were ultimately followed by food (25% versus 75%). Thus, the information presented regarding the relevance of CS2 to food was ambiguous between direct dependence and conditional independence (given CS1). If rats learnt that food was conditionally independent of CS2, given CS1, subjects of both groups should thereafter respond similarly to CS2 alone. Subjects attended to the direct food predictability of CS2, suggesting that rats treat even distal stimuli in a CS sequence as immediately relevant to food, not conditional on an intermediate stimulus. These results urge caution in representing indirect associations as conditional associations, accentuate the theoretical weight of the Markov condition in graphical models, and challenge theories to articulate the conditions under which animals are expected to learn conditional associations.

Study 2 (Bowers & Timberlake, 2018) built upon a previous attempt to show that rats represent causal maps and use such maps to reason about cause and effect (Blaisdell, Sawa, Leising & Waldmann, 2006, Science, 311(5763), 1020–1022). Using a variation on a sensory pre-conditioning procedure, Blaisdell et al. (2006) showed that feeder-directed responding to a stimulus indirectly associated with food was reduced when self-produced, consistent with their hypothesis. This was taken as evidence for the discounting of competing causes and extended to suggest a general causal reasoning capacity among rats involving mental maps of causal relations. Critics rejoined that response competition can explain these effects. We replicated the key effect but used continuous and finer-grained measurement of a broader range of behaviours. Behaviours not recorded in previous studies contradict both prior explanations. Even results cited in support of these explanations, when measured in finer detail and continuously over longer periods, show patterns not expected by either view, but supportive of a specific-process approach with attention to motivational factors. Still, the abstract prediction from Bayesian networks holds, providing a potentially complementary normative analysis. Behaviour systems theory is evoked as a firmer basis for such theories than representational-map alternatives.

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Preschool children incrementally interpret causal and concessive connectives

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Adults incrementally use discourse connectives as cues to construct a better representation of the discourse and predict the upcoming content[2]. Nevertheless, less is known about how children integrate discourse connectives. Studies showed that children acquire concessive connectors late because they are cognitively more complex than causal connectives[1]. Being offline, previous studies on children's connective comprehension rely on the end-sentence interpretation of these connectors in multi-clausal sentences that incur heavy processing costs on developing parsers with limited memory capacity. Thus, whether children can incrementally integrate discourse connectors in the course of processing is unclear. We fill in this gap with a visual-world eye-tracking study testing the interpretation of causal (*so/bu yüzden*) and concessive (*but/ama*) connectors in Turkish.

Modeled after [2] and [3], our study presented a context sentence presenting what a character wished to do (1a), followed by a critical sentence with a connector signing the fulfillment of this wish (*so/bu yüzden*) or denying it (*but/ama*) (1b) and a question explicitly asking what the character actually did (2). We examined whether children kept their gaze on the target picture after hearing the connector. We aimed to observe the immediate effect of the connector. We used the demonstrative pronoun *şunu* (this) in the target region to keep the target ambiguous. In the concessive connective condition, the participants heard the adjective contrasted with the target referent whereas the adjective in the causal connective was compatible with the target. Therefore, our assumption was that if the participants could make correct reasoning by relying on the meaning of the connector, they would shift their gaze to the target even though it is not compatible with the adjective. We tested 4-to-5-year-old children (N=23, Mean age = 4;5) and adults as the control group (N=15).

Figure 1 revealed that both children and adults moved their gaze to the target referent after the onset of the connector in both concessive and causal conditions. Generalized Additive Mixed Model (GAMM) analysis showed that adults and children showed a similar non-linear trend in concessive condition (F=1.768, p <0,14). In both causal (Figure 2) and in concessive condition (Figure 3), the looks to target increased after hearing the connector for both age groups. These results implied that 4-to-5-year-old children showed an adult-like incremental processing pattern. However, accuracy scores showed that children performed poorly compared to adults in both causal (t(22.349)=-2.7229, p <0,02) and concessive connectors (t(22.64)=-12.459,p <0,001). Children also performed poorer in concessive condition (t(35.159) = -9.6059, p <0,001). These findings indicate that children integrate connector meaning incrementally but they may not be able to rely on the connectors, especially concessive connector, to make causal reasoning. This might be because the lexico-semantic activation for the adjective might be greater than that of the discourse connective which requires both lexico-semantic and discourse integration. Children might be having difficulty suppressing this stronger meaning because of their developing inhibition skills. In conclusion, this study shows that the development of reasoning by relying on connectors seems to be linked to the development of executive function abilities.

Sample Test Item

(1a) Ali'nin can-ı	**tatlı**	bir	şey	yemek	iste-di.	
Ali-GEN heart-Poss.3sg		sweet	a	thing	eat	want- Past
'Ali wanted to eat something sweet.'						
(1b) Ama/Bu yüzden	şu-nu		yedi.			
But/so	that-ACC		eat-Past			
'But/so he ate that one.'						
(2) Sence Ali	hangi-si-ni		yedi?			
To you Ali	which-Poss.3sg-Acc		eat-Past			
'Which one do you think Ali ate?'						

Figure 1: Proportion of looks in each condition by age group

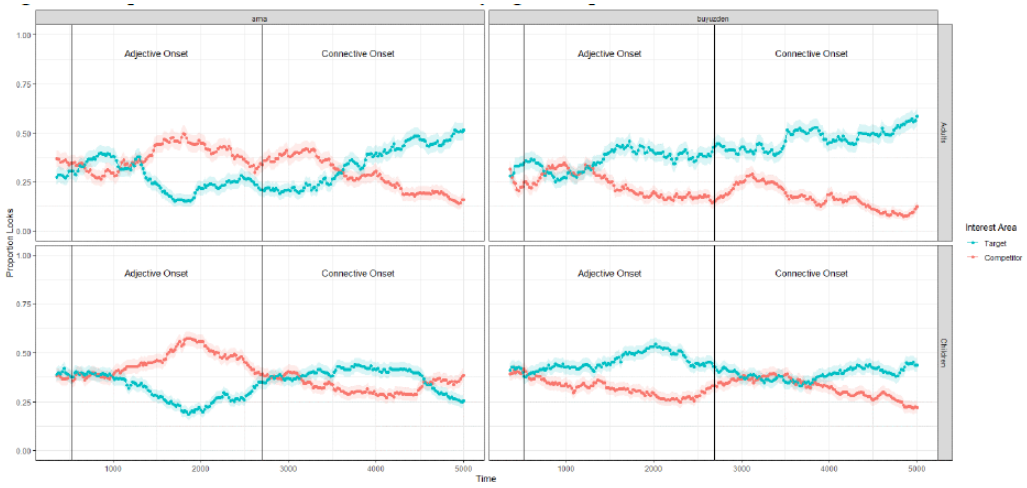
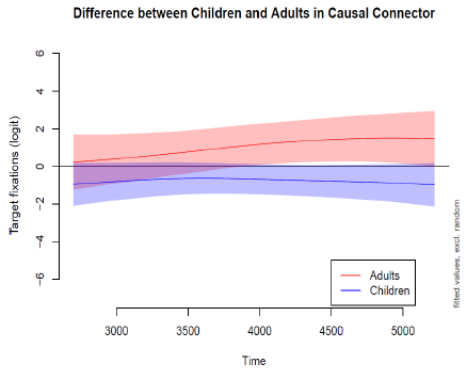
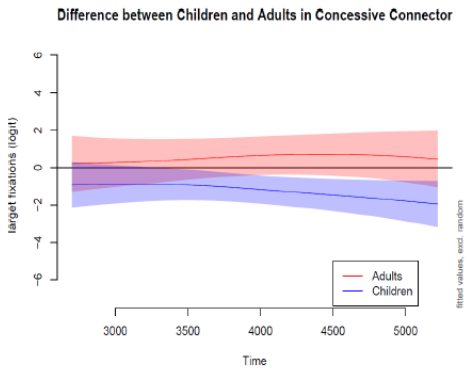


Figure 2: Smooths for causal connective "Bu yüzden"

Figure3: Smooths for concessive connective "Ama"





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Children can interpret counterfactual conditionals incrementally using morpho-syntactic cues

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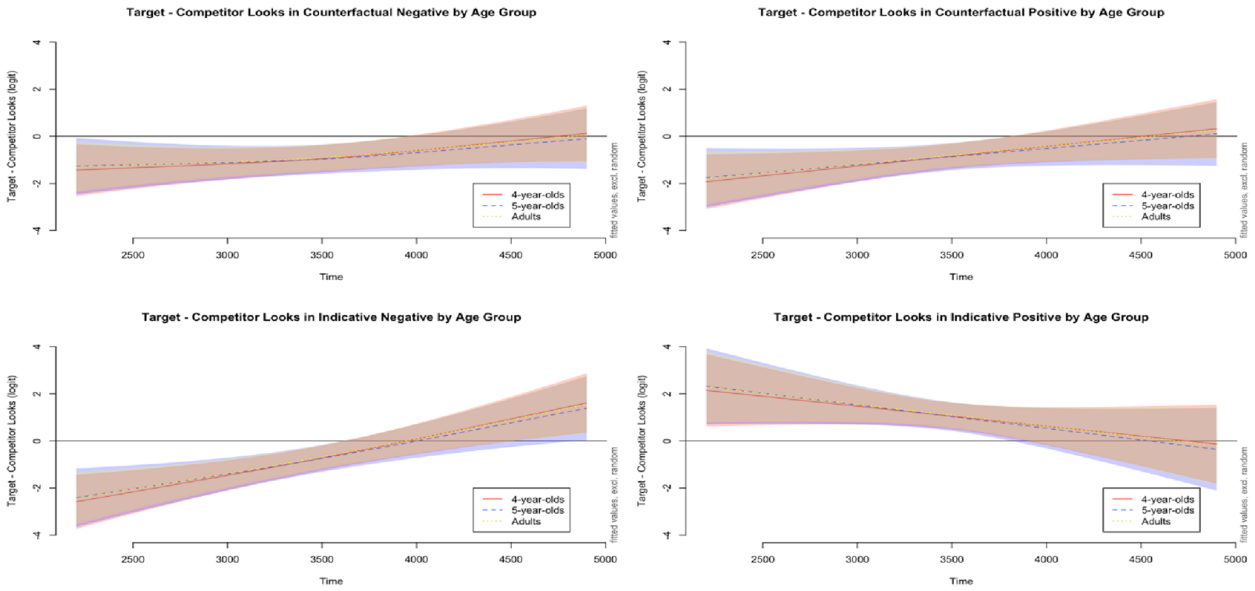
Children can incrementally use morphosyntactic cues for meaning assignment (e.g., thematic roles, passivation) by age 4[1]. Also, they can reason using logical connectives such as *and*, or and *not* by age 3.[2] What about more complex situations requiring inferencing via both morphosyntax and conditional logical connective: counterfactuals? Counterfactuals might be more costly to process as they require an access to alternative hypothetical possibilities and their implicatures. Previous studies have not addressed children's processing patterns of counterfactuals, and they yielded mixed findings about when children could interpret counterfactual conditionals at adult-like level. Whereas some studies stated that children as young as age 4 could reason counterfactually[3] [4], others reported that it is not until age 6-7 for children to interpret counterfactual situations in an adult-like fashion.[5] [6] The difference among these studies may be methodological as they all relied on different offline measures incurring heavy processing demands where children both need to both comprehend some stories including counterfactual situations and keep in mind the inferences of these situations. Therefore, it is possible that children process these structures on the fly, but they fail to retrieve their initial interpretation until the end of the utterance. We address this issue for the first time, examining children's real-time processes in counterfactual conditional structures. We conducted an eye-tracking experiment using visual world paradigm (VWP) to investigate (i) when children can reason adult-like using counterfactuals and (ii) whether they can incrementally integrate the morphosyntax of counterfactuals in a language that encodes both the conditional and counterfactual meaning in concatenated verbal suffixes (e.g., Turkish; *gel-se-(y)di/come-Cond-Past* for counterfactual conditional meaning; *gel-ir-se/come-Aor-Cond* for indicative conditional meaning). 4-year-old (M_{AGE} = 4:07; N = 14) and 5-year-old (M_{AGE} = 5:04; N = 9) children, and adults (N = 14) viewed a scene with two referents representing the real-world and the alternative one while they heard utterances in four conditions: counterfactual-with-negative-outcome (CN), counterfactual-with-negative-outcome (CP), indicative-with negative-outcome (IN), and indicative-with-positive-outcome (IP) (Table 1). Following each utterance, they were asked a comprehension question regarding that utterance. The eye-tracking data was analyzed using a Generalized Additive Mixed Model (GAMM). The smooth terms of GAMM revealed that children and adults attended the target referent more than the competitor referent after the offset of the verb conjugation in all conditional sentences (Figure 1). This result suggests that children as young as age 4 can interpret counterfactual conditionals incrementally right after they heard counterfactual morphosyntax as adults do. We also analyzed the participants' responses to the comprehension questions using a Generalized Linear Mixed Model (GLMM). The summary of GLMM showed that the participants found the questions after CN condition harder such that their performances drop significantly in that condition. However, there was no significant difference between the other conditions (CP, IP, and IN). To our knowledge, this is the first piece of evidence showing that the morphosyntax marked on verbs quickly leads to complex inferences such as generating hypothetical alternative worlds for counterfactual reasoning not only in adults but also in very young children.

Table 1: Examples of scene setting sentence, experimental sentences, and comprehension question.

Scene-Setting Sentences	Garaj-da araba ve bisiklet var-(dı/∅). Garage-*Loc* car-*Nom* and bicycle-*Nom* exist-(*Past/Aor*) There were/are a car and a bicycle in the garage.	Target
Counterfactual Negative	Ahmet araba-(y)ı sür-se-(y)di, işe zamanında yetiş-ecek-ti. Ahmet-*Nom* car-*Acc* drive-*Cond*-*Past* job-*Dat* on time catch-*Fut*-*Past* If Ahmet had driven the car, he would have been on time for the job.	Bicycle
Counterfactual Positive	Ahmet bisiklet-i sür-se-(y)di, işe geç kal-acak-tı. Ahmet-*Nom* bicycle-*Acc* ride-*Cond*-*Past* job-*Dat* late become-*Fut*-*Past* If Ahmet had ridden the bicycle, he would have been late for the job.	Car
Indicative Negative	Ahmet bisiklet-i sür-er-se, işe geç kal-acak. Ahmet-*Nom* bicycle-*Acc* ride-*Aor*-*Cond* job late become-*Fut* If Ahmet rides the bicycle, he will be late for the job.	Car
Indicative Positive	Ahmet araba-(y)ı sür-er-se, işe zamanında yetis-ecek. Ahmet-*Nom* car-*Acc* drive-*Aor*-*Cond* job on time catch-*Fut* If Ahmet drives the car, he will be on time for the job.	Car
Comprehension Question	Sen-ce Ahmet hangisi-(n)i sür-(dü/ecek)? You-*Abl* Ahmet-*Nom* which-*Acc* drive/ride-(*Past/Fut*) Which one do you think Ahmet (did/will) drive/ride?	

Figure 1: Smooth plots of the conditions by each age group



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Important Information

Venue
Elif Hanım Hotel
Phone Number:(+90) 252 243 44 44
Address:Akyaka Mahallesi, Koyuncu Sokak No:26 Akyaka/Muğla
Email: info@elifhanimhotels.com.tr

How to get there
How to get to Elif Hanim Hotel: The best way to get to Gökova-Akyaka is to fly to Dalaman Muğla Airport and take the airport shuttle to Marmaris that will drop you at Gökova Junction. It is a short taxi-drive from the junction.

If you plan to come by **bus**, you can buy a bus ticket to Marmaris. It is best to tell the bus driver to let you out at Gökova Junction when boarding the bus. You can find a taxi at least until midnight to Elif Hanim Hotel. You can call Akyaka Taxi by +90 (532) 666 57 89 (https://www.akyakataksi.com/).

To transfer from Dalaman Airport to Akyaka, you can use Havaş Bus Services. Please check the link below for the schedules of Havaş Buses.
From Dalaman Airport
Please check the website below for Havaş Bus Services
https://havas.net/en/bus-services

Local Restaurants
1. *Hasan Usta Çorba ve Pide Kebap Salonu*
+90 252 243 56 76
Akyaka Mah. Nergis Sokak, Akyaka

2. *Febiha 1921*
+90 542 763 82 28
Karanfil Sk. 7/A, Akyaka

3. *Kristal Restaurant*
+90 532 132 14 24
Atatürk Cd, Akyaka

4. *Halil in Yeri*
+90 252 243 51 73
İnişdibi Cd. No. 48, Akyaka

5. *Cennet restaurant*
+90 532 570 64 93
İnişdibi Cd., No:57 Ula, Akyaka