

A probabilistic approach to 3 person medical shared decision- making

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Outline

- Introduction
- Doctor's Detailedness
- Patient and Family member's emotions
- The Decision model
- Conclusion

Introduction

- In most (not too advanced) colorectal cancer patients, the treatment usually begins with a guaranteed surgery
- It is after the surgery that we have uncertainty:
- Depending on the result of the surgery, different options are available for the patient.
- For our case (colorectal cancer) we take the following surgery results:
 - Complete Resection with Clean Margins, Resection with Positive Margin, Lymph Node Involvement, Metastasis Detected
- And the following treatment options:
 - chemotherapy, additional surgery, radiation therapy, targeted therapies

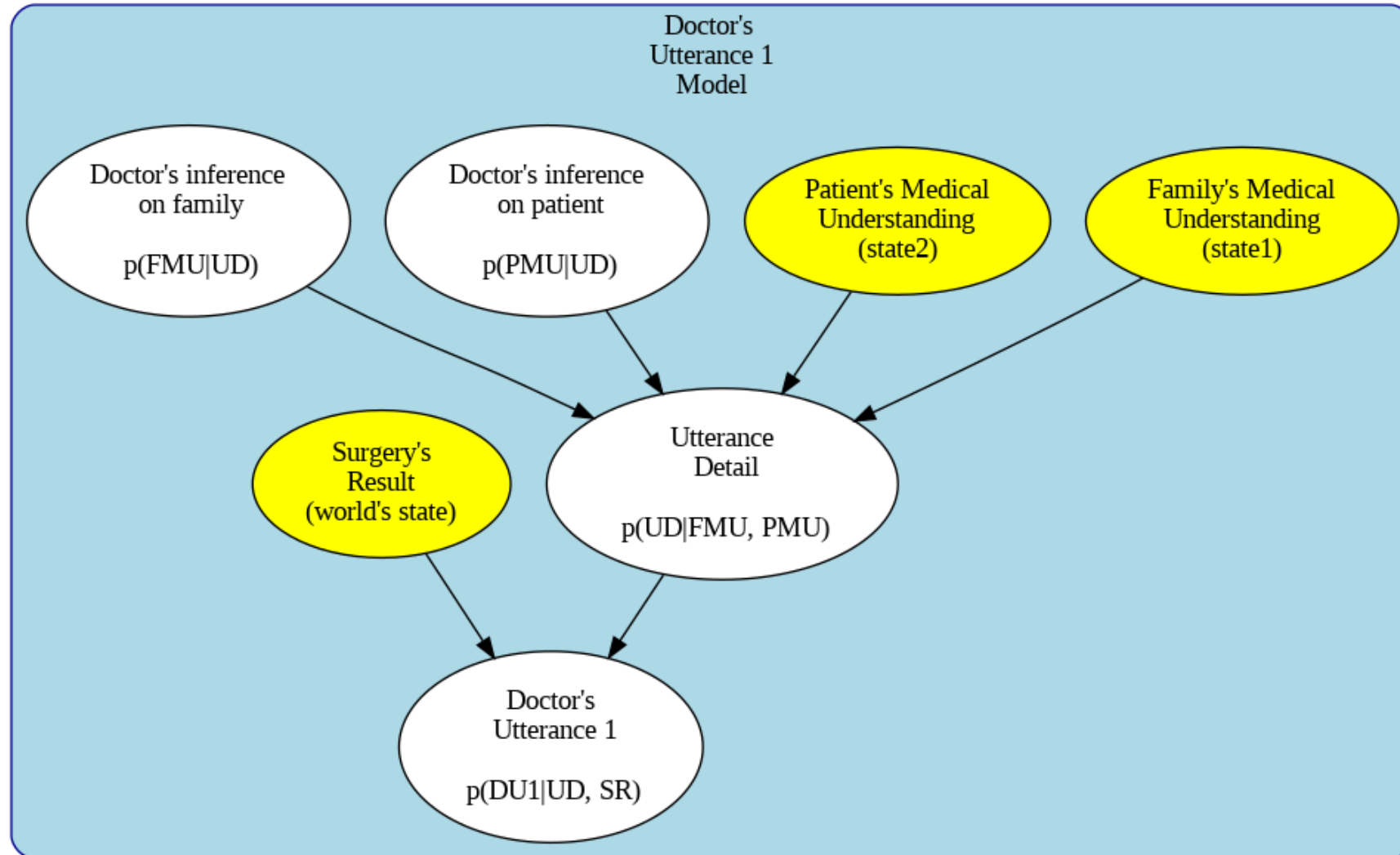
Doctor's Detailedness

- The doctor first decides on 'how detailed' he needs to explain the situation. Then he decides on his utterance
- The doctor receives a tuple of 3 values as the state of the world:

```
var states = {  
  SR   : 'Complete Resection with Clean Margins', // surgery result  
  PMU  : 1, // patient's medical understanding  
  FMU  : 3, // family's medical understanding  
}  
  
doctor_speaker1(states.PMU, states.FMU, states.SR, 0.5)
```

- The doctor has high costs for longer details

Doctor's Detailedness



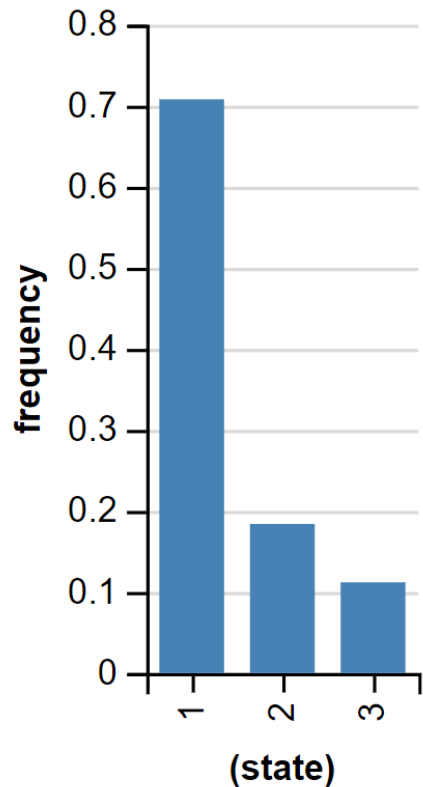
Doctor's Detailedness

```
var doctor_speaker1 = function(state1, state2, worldState, beta) {
  Infer({model: function(){
    var detailLevel = uniformDraw(utteranceDetails)
    var L0_patient = Patient(detailLevel)
    var L0_family = Family(detailLevel)
    var utility = {
      patient_epistemic: L0_patient.score(state1),
      family_epistemic: L0_family.score(state2)
    }
    var speakerUtility = beta * utility.patient_epistemic + (1-beta) * utility.family_epistemic - cost1(detailLevel)
    factor(alpha * speakerUtility)
    return detailLevel
  })
});
```

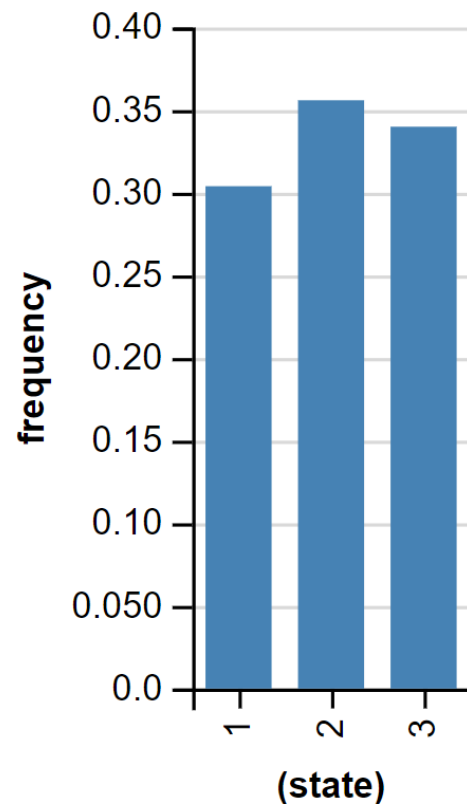
Doctor's Detailedness: how much the doctor cares for each agent?

Here I took PMU=low, FMU=high, SR="Complete Resection with Clean Margins"

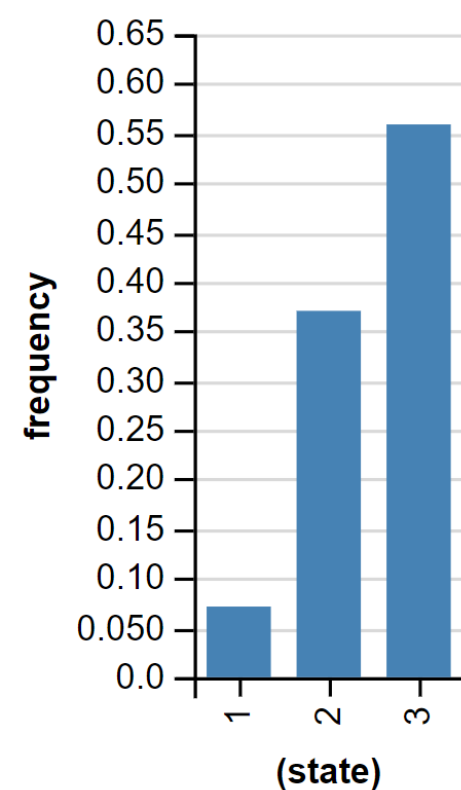
beta = 0.1



beta = 0.5



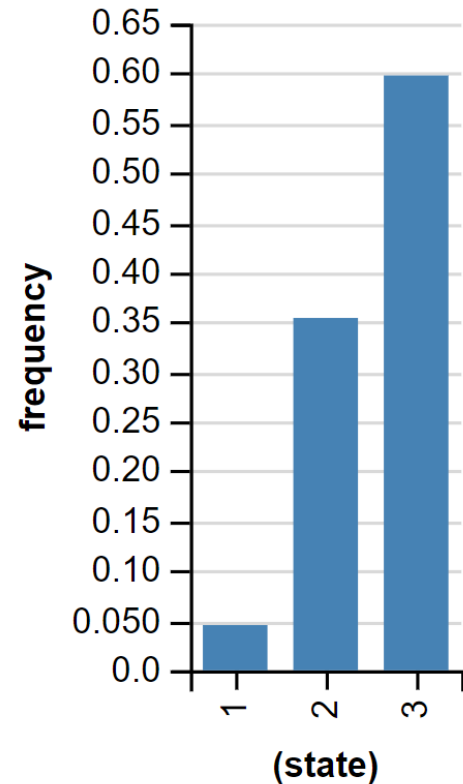
beta = 0.9



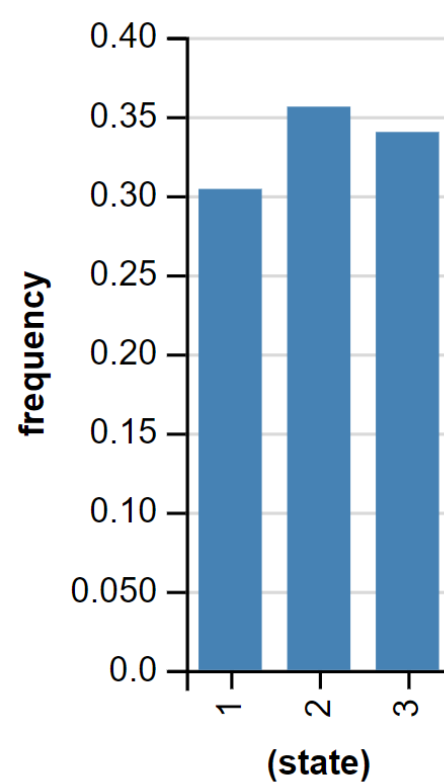
Doctor's Detailedness: medical understanding's effect on doctor's detailedness

Here I took $\beta=0.5$ and SR="Complete Resection with Clean Margins"

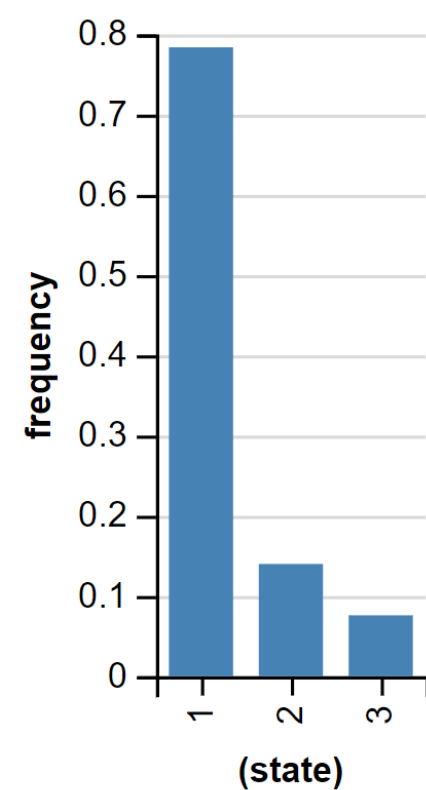
PMU, FMU = low



PMU=low, FMU=high



PMU, FMU=high



Doctor's Detailedness: selecting the final utterance

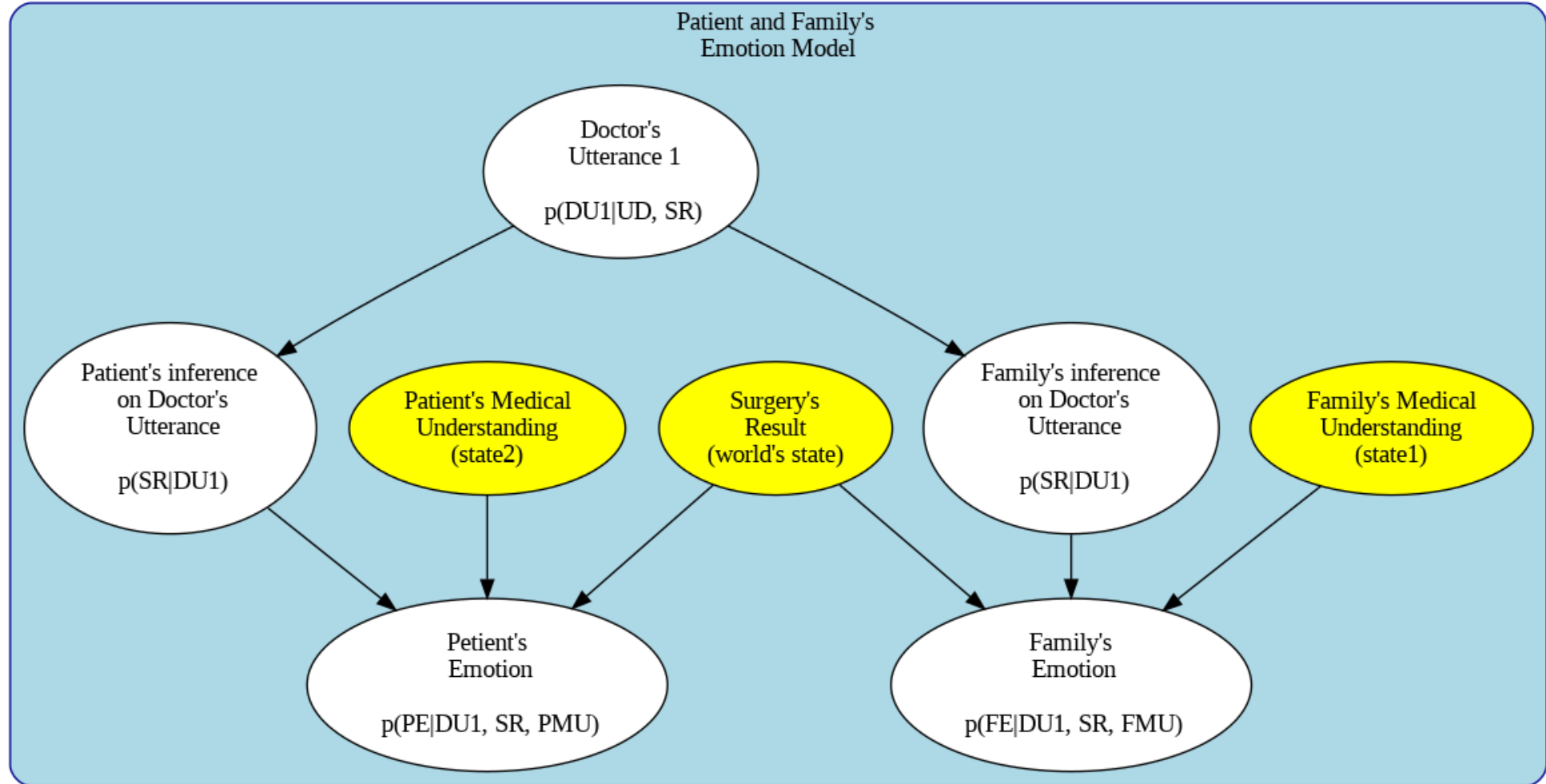
Here we took PMU=low, FMU=high, beta=0.9, SR="Complete Resection with Clean Margins"

(state)	probability
The surgical excision achieved clear margins. There are no remaining cancerous cells at the perimeter of the resected tissue. Available treatment options are chemotherapy (usually most beneficial in getting rid of all cells), radiation therapy, and targeted therapies. As a result, I see your situation optimistically. In you decision, note that chemotherapy causes nausea and vomiting, hair loss, fatigue, and infection. Radiation therapy results in skin problems, fatigue, hair loss, bladder issues. And targeted therapies might cause skin problems, blood pressure, fatigue, and kidney function problems later on.	0.5582547331095263
The surgical excision achieved clear margins. There are no remaining cancerous cells at the perimeter of the resected tissue. Available treatment options are chemotherapy (usually most beneficial in getting rid of all cells), radiation therapy, and targeted therapies.	0.3715896467490157
The surgical excision achieved clear margins.	0.07015562014145843

Patient and Family member's emotions

- The emotion of the family member and the patient depends on the doctor's detailedness (from the previous section) and the world's state (FMU, PMU, and inferred SR)
- The emotional reaction (the amount of stress) follows a truncated beta distribution prior (that bounds the values between 0 and 1).
- We the parameters of the truncated beta prior depends on whether of not the agent ha received 'sufficient' information from the doctor and on the DR.

Patient and Family member's emotions



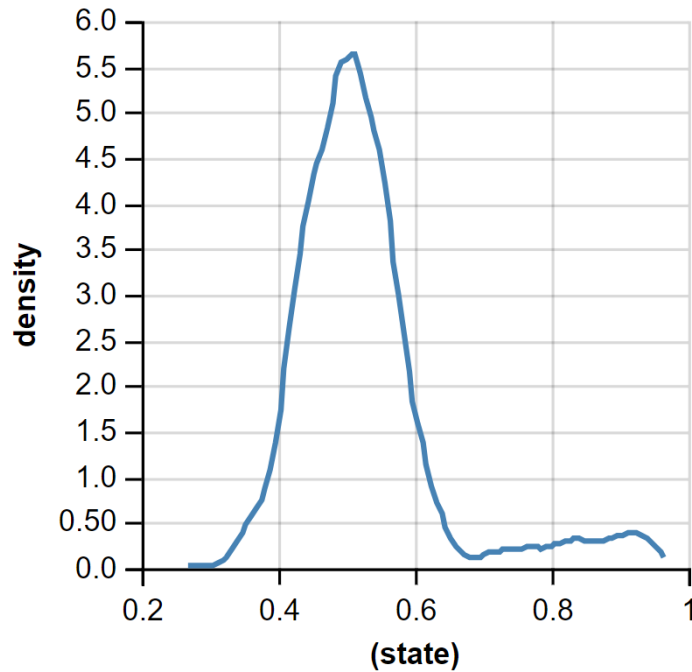
Patient and Family member's emotions

```
var patient_emotion = cache(function(state1, detailLevel, SR) {  
  Infer({model: function(){  
    var stateP = uniformDraw(states1);  
    var inferred_worldState = listener(state1, stateP, detailLevel);  
    observe(inferred_worldState, SR);  
    var emotion = emotional_reaction(state1, SR, detailLevel);  
    return emotion  
  }})  
});
```

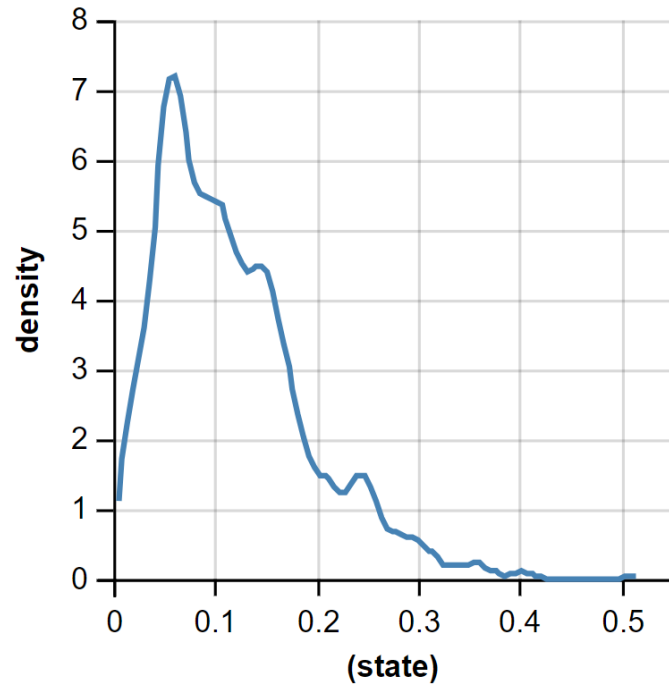
Patient and Family member's emotions

Assuming the surgery went well and SR="Complete Resection with Clean Margins"

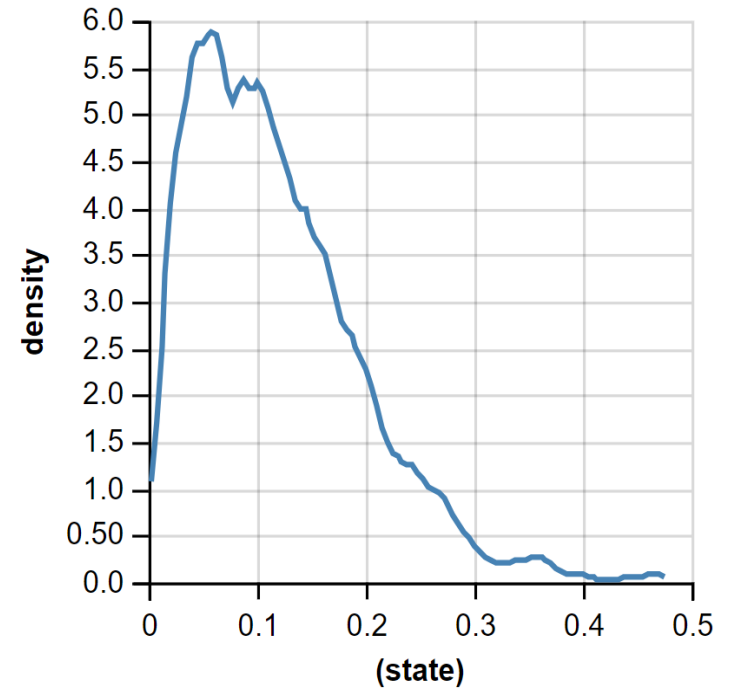
PMU=low, UD=low



PMU=low, UD=high



PMU=high, UD=low

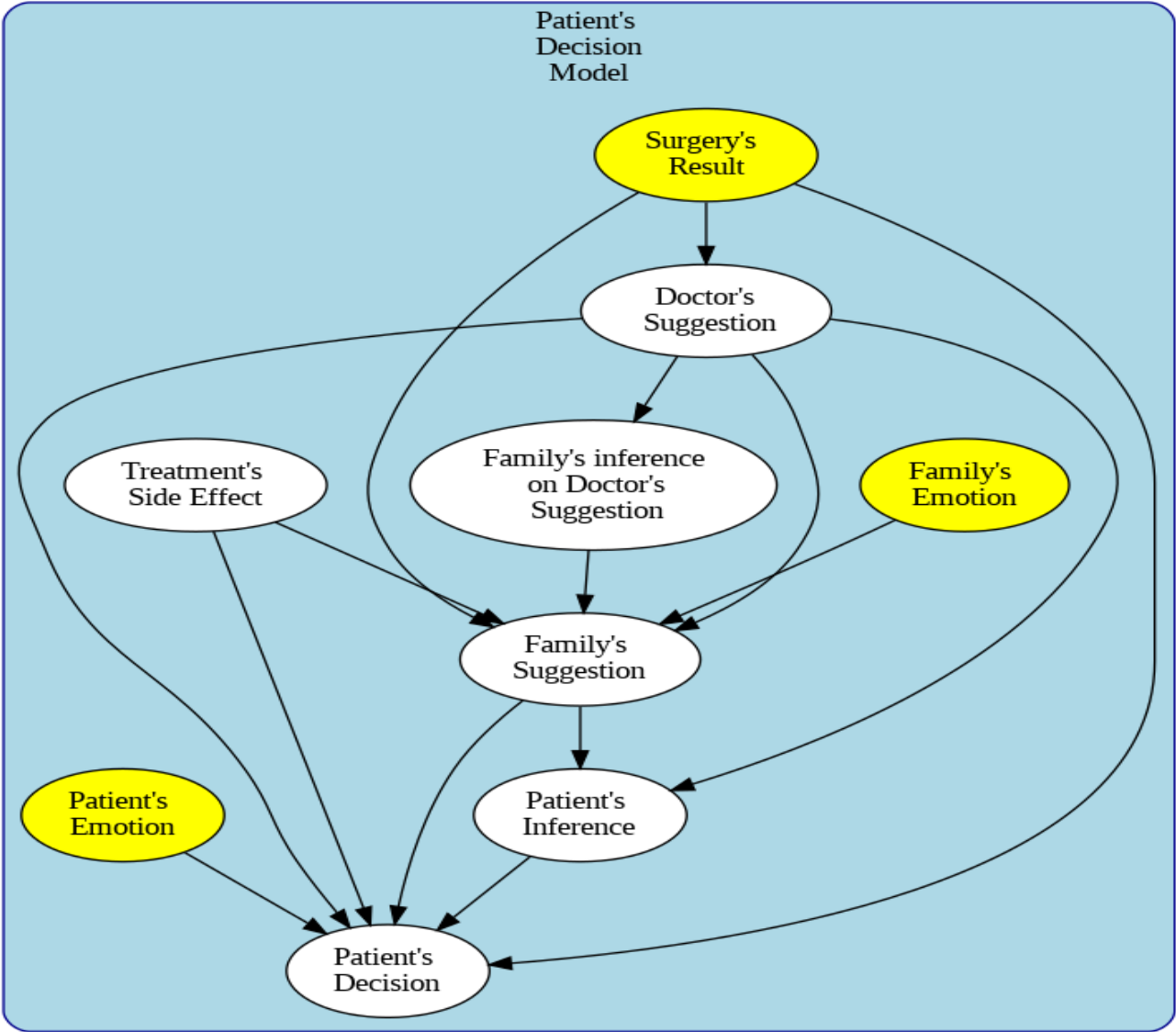


Note: both family and patient follow similar models here. So I only demonstrate the results of one model

The Decision Model

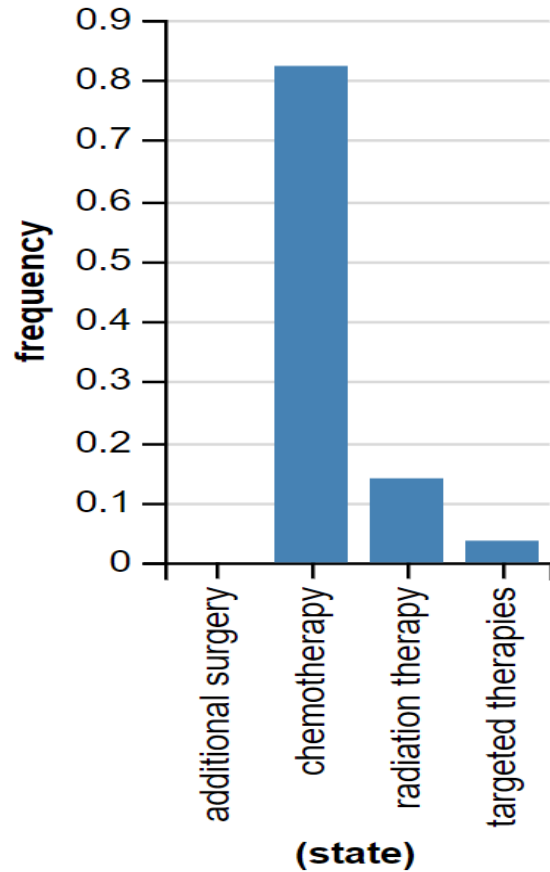
- Now, the doctor and the family member and the doctor each provide a suggestion to the patient about the treatment they find most useful
- The patient hears their suggestions and makes a decision about their preferred treatment
- In this stage, the state of the world is now taken as SR, PE, and FE. We no longer consider FMU and PMU to be a factor here.

The Decision Model

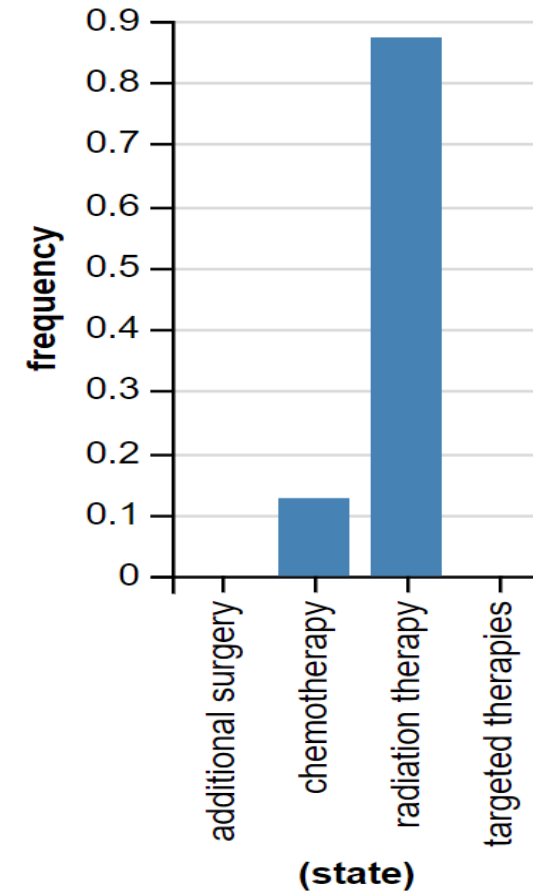


The Decision Model: Doctor's Suggestion

SR=Complete Resection with Clean Margins



SR=Resection with Positive Margins



The Decision Model: Side effects costs

```
• var treatmentSideEffects = {  
  "chemotherapy"      : ["nausea and vomiting", "hair loss", "fatigue", "infection"],  
  "additional surgery" : ["infection", "bleeding", "anesthesia", "physical function"],  
  "radiation therapy"  : ["skin problems", "fatigue", "hair loss", "bladder issues"],  
  "targeted therapies" : ["skin problems", "blood pressure", "fatigue", "kidney function"]  
}  
var sideEffectCost = function(sideEffect){  
  return sideEffect==="nausea and vomiting"?  
    0.4 :sideEffect==="hair loss"?  
    0.2 :sideEffect==="fatigue"?  
    0.15 :sideEffect==="infection"?  
    0.5 :sideEffect==="bleeding"?  
    0.5 :sideEffect==="anesthesia"?  
    0.1 :sideEffect==="physical function"?  
    0.6 :sideEffect==="skin problems"?  
    0.2 :sideEffect==="blood pressure"?  
    0.2 :sideEffect==="bladder issues"?  
    0.3 :sideEffect==="kidney function"?  
    0.6 : 0  
}
```

chemotherapy cost is 1.25

radiation therapy cost is 0.85

additional surgery cost is 1.7

targeted therapies cost is 1.15

The Decision Model: stressed side effect costs

```
var stressedSideEffectCost = function(sideEffect, stress){  
  return sideEffect==="nausea and vomiting"?  
    0.4 :sideEffect==="hair loss"?  
    0.2+5*stress :sideEffect==="fatigue"?  
    0.15 :sideEffect==="infection"?  
    0.5 :sideEffect==="bleeding"?  
    0.5 :sideEffect==="anesthesia"?  
    0.1 :sideEffect==="physical function"?  
    0.6 :sideEffect==="skin problems"?  
    0.2 :sideEffect==="blood pressure"?  
    0.2 :sideEffect==="bladder issues"?  
    0.3 :sideEffect==="kidney function"?  
    0.6 : 0  
}
```

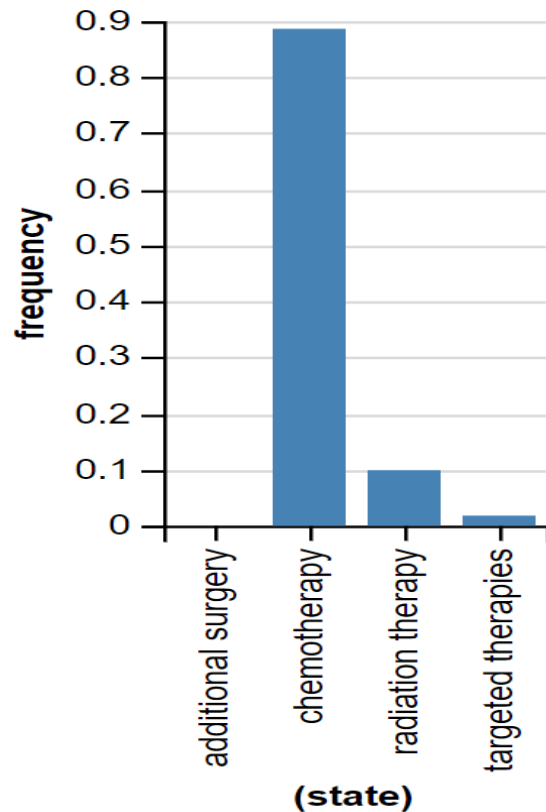
The Decision Model: stressed side effect

```
var patient_decision = cache(function(state, stress) {
  Infer({model: function(){
    var treatment = uniformDraw(treatments)
    var patient_prior = PatientCure(treatment)
    var suggestions = patient_listener(treatment)
    var utility = {
      patient: patient_prior.score(state),
      suggestions: suggestions.score(state)
    }
    var speakerUtility = theta * utility.patient +
      (1-theta) * utility.suggestions - stressedTreatmentCost(treatment, stress)
    factor(alpha2 * speakerUtility)
    return treatment
  }})
});
```

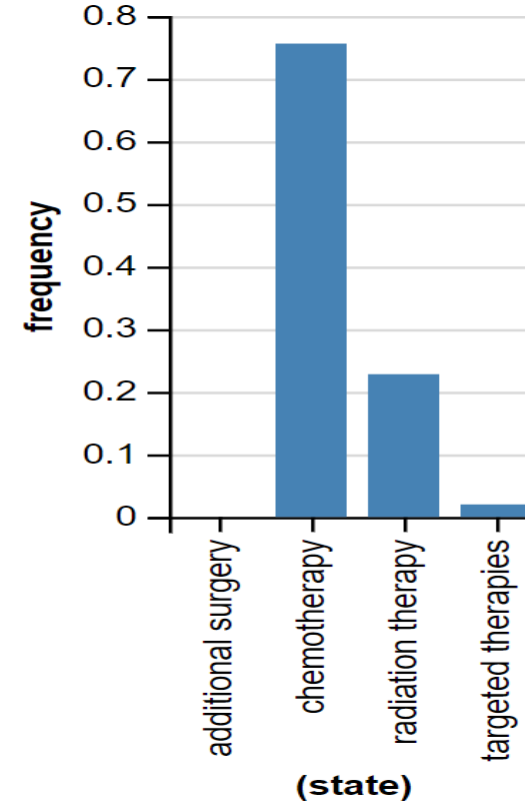
The Decision Model: Family's Suggestion

We assume SR=Complete Resection with Clean Margins

without side effect cost



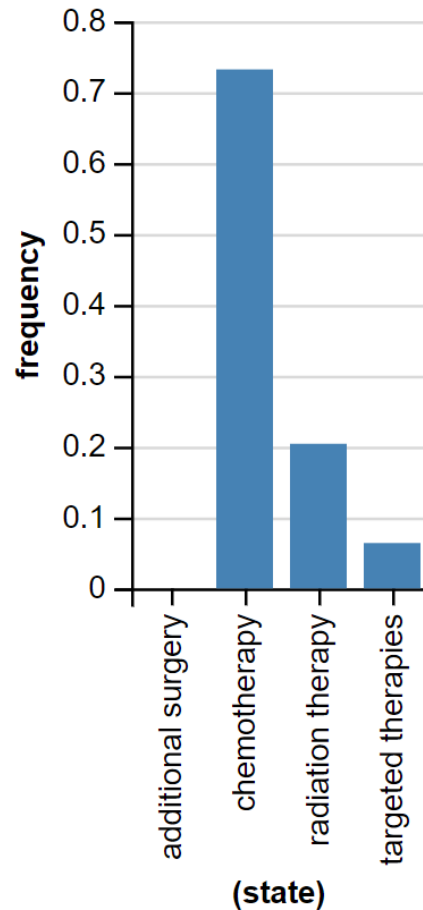
with side effect cost



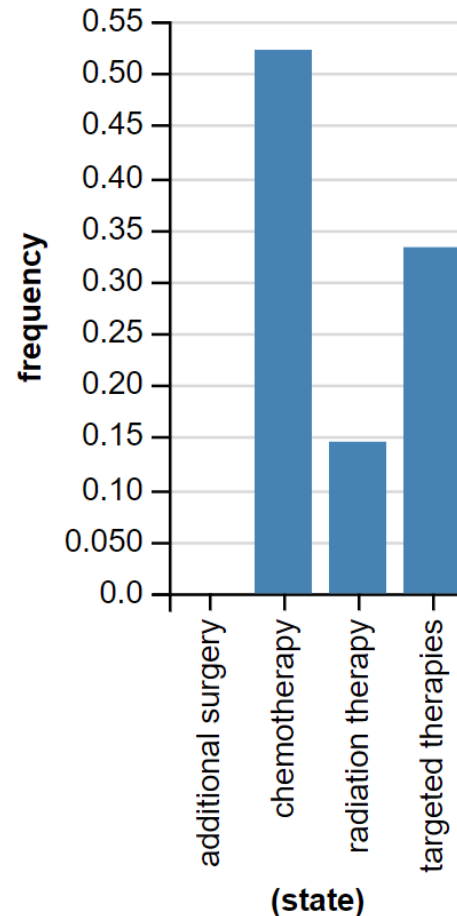
The Decision Model: Patient's Decision

We assume SR=Complete Resection with Clean Margins

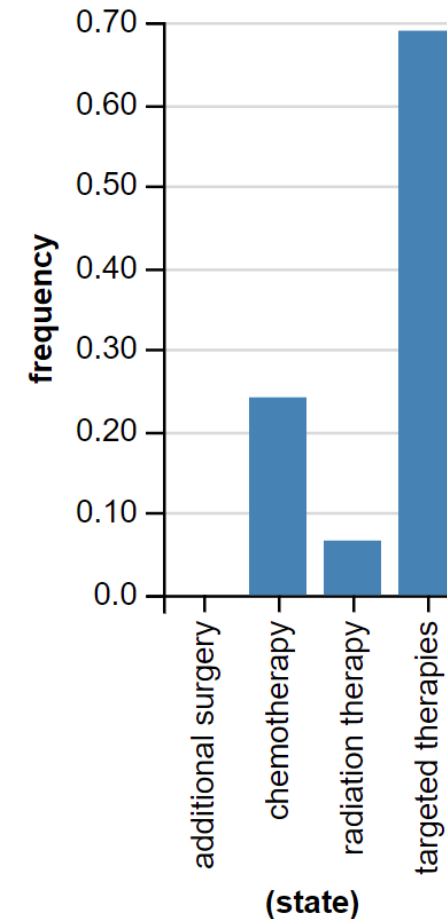
stress = 0.1



stress = 0.5



stress = 0.9



Conclusion

- In this project, I analyzed different aspects of medical shared decision making and 3-person conversation.
- We defined a model of a doctor's detailedness
- We defined a model of patient and family member's emotions
- In the end, we created a shared decision-making model

References

- Kosmider, S., & Lipton, L. (2007). Adjuvant therapies for colorectal cancer. *World Journal of Gastroenterology: WJG*, 13(28), 3799.
- Compton, C. C., Fielding, L. P., Burgart, L. J., Conley, B., Cooper, H. S., Hamilton, S. R., ... & Willett, C. (2000). Prognostic factors in colorectal cancer: College of American Pathologists consensus statement 1999. *Archives of pathology & laboratory medicine*, 124(7), 979-994.
- Degen, J. (2023). The rational speech act framework. *Annual Review of Linguistics*, 9, 519-540.