

**MODELING RISKY CHOICES WHEN PROBABILITIES OF OUTCOMES ARE
VERY LOW AND VERY HIGH:
CHOICES REGARDING PRENATAL DIAGNOSIS OF DOWN SYNDROME.**

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Objectives

1) Utilities of outcomes according to the Expected Utility Model

- ◆ Relevance of the Expected Utility Model ?

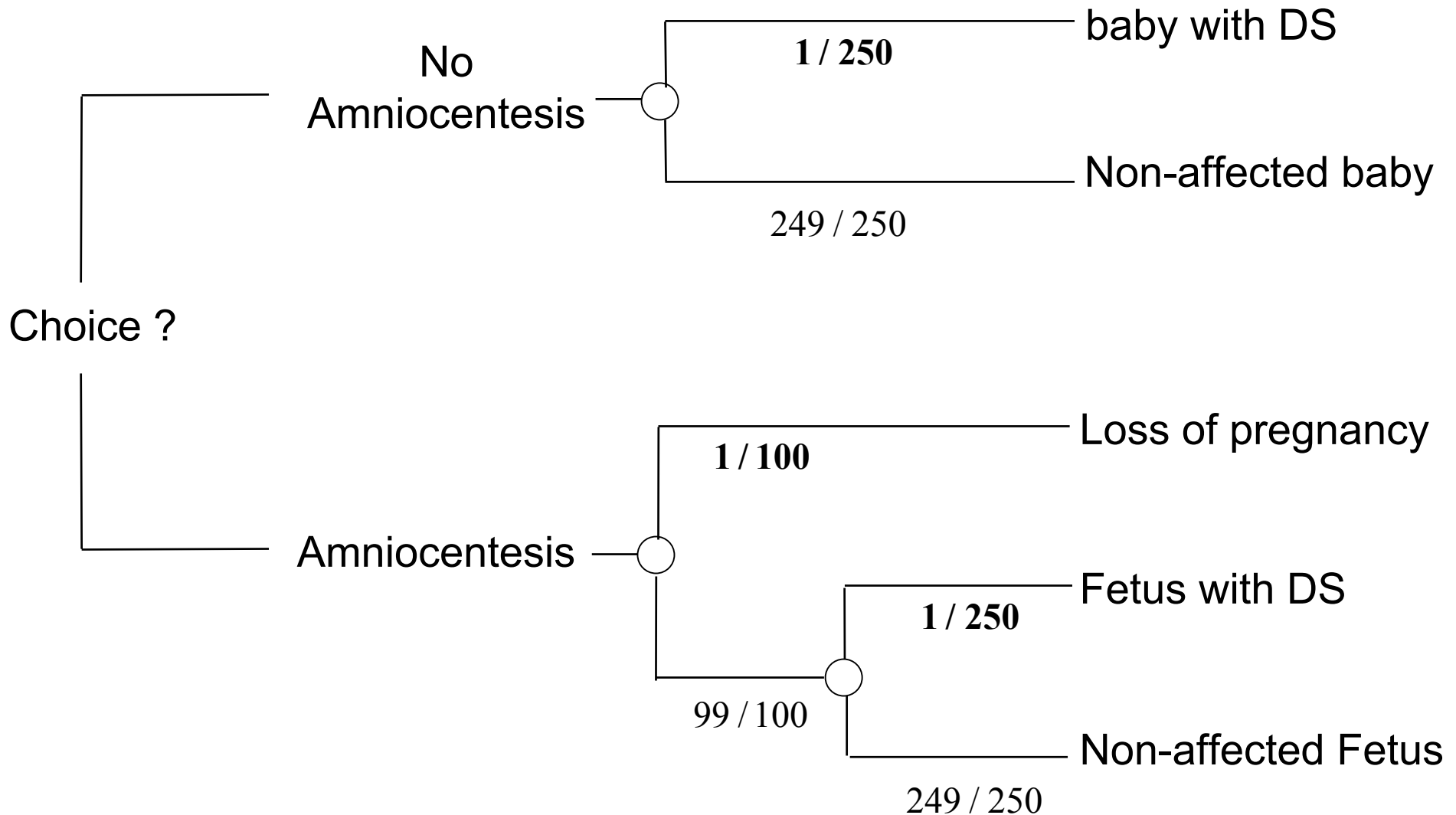
2) Analysis of observed choices according to :

- ◆ Utility values
- ◆ Probabilities of outcomes

3) Elicitation of the probability weighting function

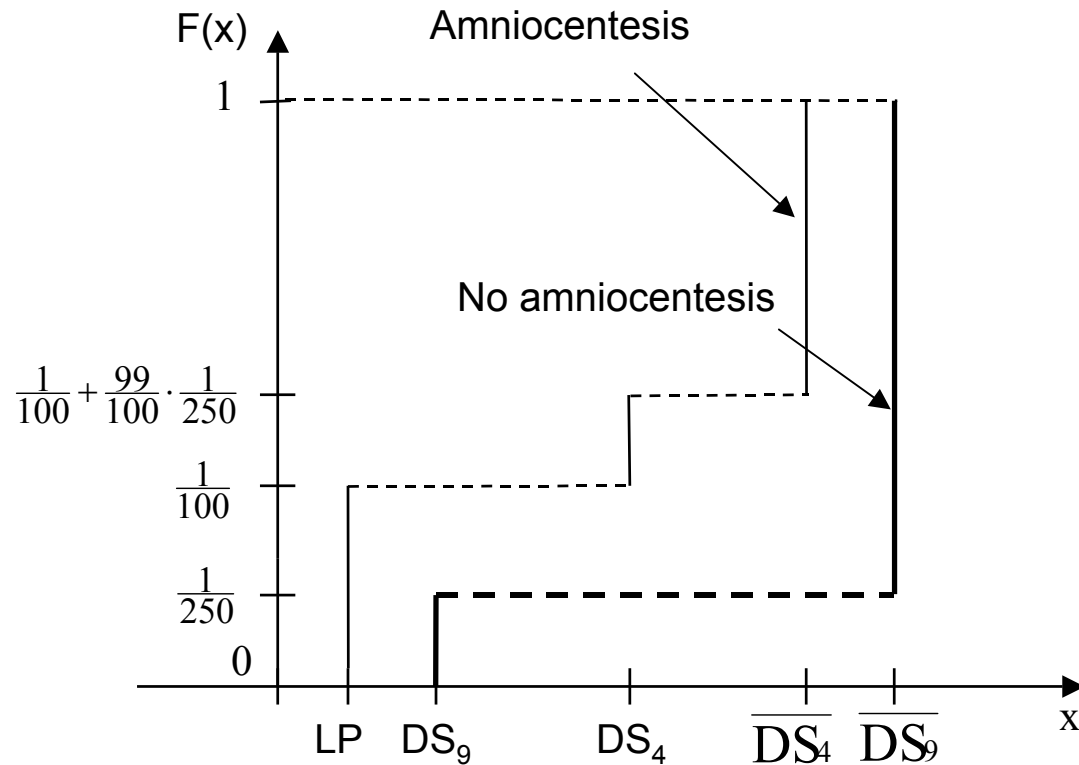
- ◆ Rank Dependent Utility Theory

➡ **Choice between « no amniocentesis » and « amniocentesis »**



→ **Case # 1.**

Worst outcome: loss of pregnancy due to amniocentesis (LP)



Notation

LP: loss of pregnancy

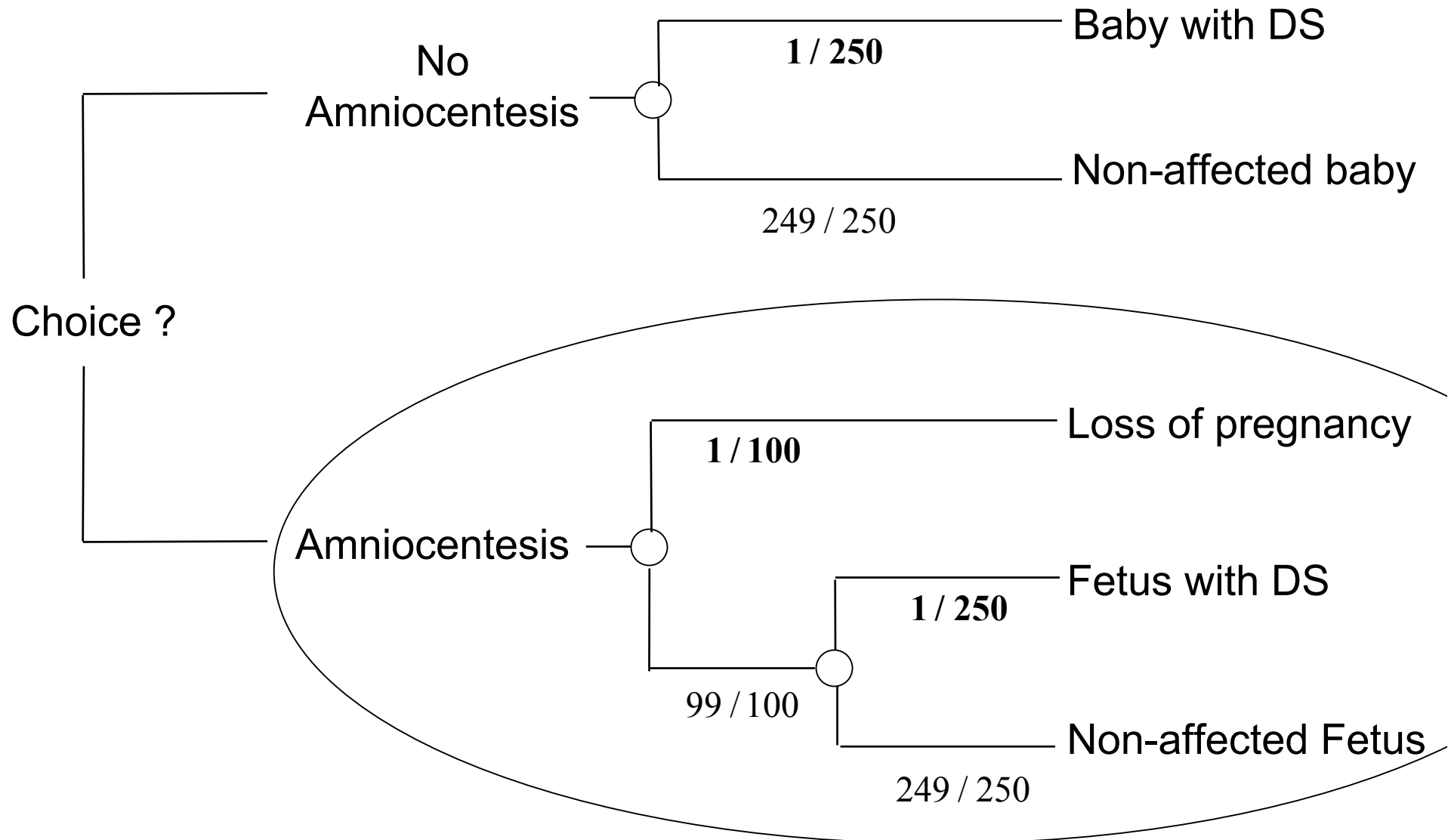
DS_9 : birth of a baby with DS

DS_4 : fetus with DS at 4 months

$\overline{DS_4}$: non-affected fetus at 4 months

$\overline{DS_9}$: birth of a non-affected baby

➡ **Choice between « no amniocentesis » and « amniocentesis »**



→ **Case #2. Worst outcome: birth of a baby with DS (DS₉)**

1) Risk of DS = 1:250

◆ $u(\text{DS}_9) = 0$ and $u(\overline{\text{DS}_9}) = 1$

◆ Expected utility of « amniocentesis »

$$U(A) = \frac{1}{100} \cdot u(\text{LP}) + \frac{99}{100} \cdot \left[\frac{1}{250} \cdot u(\text{DS}_4) + \frac{249}{250} \cdot u(\overline{\text{DS}_4}) \right]$$

◆ Expected utility of « no amniocentesis »

$$U(\overline{A}) = \frac{1}{250} \cdot u(\text{DS}_9) + \frac{249}{250} \cdot u(\overline{\text{DS}_9}) = \frac{249}{250}$$

◆ **A** \succ **\overline{A}** **if:**

(i) $u(\overline{\text{DS}_4}) \in]0.996; 1[$

(ii) $u(\text{LP}) \in]0.6; 1[$

→ **Case #2. Worst outcome: birth of a baby with DS (DS₉)**

2) Risk of DS = 1:700

♦ $A \succ \bar{A}$ if:

(i) $u(\overline{DS_4}) \in]0.999; 1[$

(ii) $u(LP) \in]0.857; 1[$

3) Risk of DS = 1:100

♦ $A \succ \bar{A}$ if:

(i) $u(\overline{DS_4}) \in]0.989; 1[$

(ii) $u(LP) \in]0; 1[$

The sample (n = 78)

1) Selection criteria

- ◆ Not pregnant
- ◆ Age: 25-35
- ◆ At least one child

2) Face-to-face interview

- ◆ Elicitation of utility values
 - What are the most and the worst outcomes ?
 - Standard Gamble method
- ◆ Elicitation of choice (Decision Board)
 - 3 values of risk of DS: 1:700, 1:250, and 1:100

→ **Data analysis (n = 64)**

1) **14 women excluded** from the sample (n = 78)

♦ $u(x_i) = 0$ or $u(x_i) < 0$ or $u(x_i) > 1$

2) **Two groups** according to the worst outcome

♦ Group 1 (n = 46): birth of a baby with DS

♦ Group 2 (n = 18): loss of pregnancy

1) Worst outcome: birth of a baby with DS (n = 46)

◆ $A_{\text{obs}} \succ \bar{A}_{\text{obs}}$

Risk of DS	A	\bar{A}	A ~ \bar{A}
1:700	37	9	-
1:250	40	5	1
1:100	41	5	-

◆ **Risk of DS = 1:250**

	A	\bar{A}	
$u(\text{LP})_{\text{med}}$	0.925	0.045	(p<0.003)
$u(\text{DS}_4)_{\text{med}}$	0.985	0.64	(p<0.003)
$u(\bar{\text{DS}}_4)_{\text{med}}$	0.985	0.805	(p<0.004)

→ Discrepancy between observed and theoretical choices (n=22)

20 chose A **although** $u(\bar{\text{DS}}_4) \notin]0.996; 1[$ and $u(\text{LP}) \notin]0.6; 1[$

→ Possible consistency with EUT (n=20)

$u(\bar{\text{DS}}_4) > 0.97$ **but** $u(\bar{\text{DS}}_4) > 0.996$?

2) Worst outcome: loss of pregnancy (n = 18)

◆ $\bar{A}_{\text{obs}} \succ A_{\text{obs}}$

Risk of DS	A	\bar{A}
1:700	5	13
1:250 } 1:100 }	8	10

◆ **Risk of DS: 1:250 or 1:100**

	A	\bar{A}	
$u(\text{DS}_9)_{\text{med}}$	0.413	0.448	(p<0.88)
$u(\text{DS}_4)_{\text{med}}$	0.413	0.465	(p<0.88)
$u(\overline{\text{DS}}_4)_{\text{med}}$	0.985	0.985	(p<0.69)

→ Rank Dependent Utility Theory

- ◆ $x_1 \prec x_2 \prec x_3$ avec $I_p = (x_1, x_2, x_3; p_1, p_2, p_3)$

↳ Decision weight : $h_i(p) = g\left(\sum_{j=i}^n p_j\right) - g\left(\sum_{j=i+1}^n p_j\right)$

↓

$$\text{RDU}(I_p) = h_1(p) \cdot u(x_1) + h_2(p) \cdot u(x_2) + h_3(p) \cdot u(x_3)$$

→ Elicitation of the probability weighting function

1) Estimation of $g(p) = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}}$ (Tversky et Kahneman, 1992)

2) Calculation of RDU (\bar{A}) and RDU (A)

◆ $\gamma_j \in]0; 2[$

◆ For each γ_j , comparison of observed choices to theoretical choices

When $A_{\text{obs}} \succ \bar{A}_{\text{obs}}$

or

$\bar{A}_{\text{obs}} \succ A_{\text{obs}}$

$$\Leftrightarrow \text{RDU}(A) > \text{RDU}(\bar{A})$$

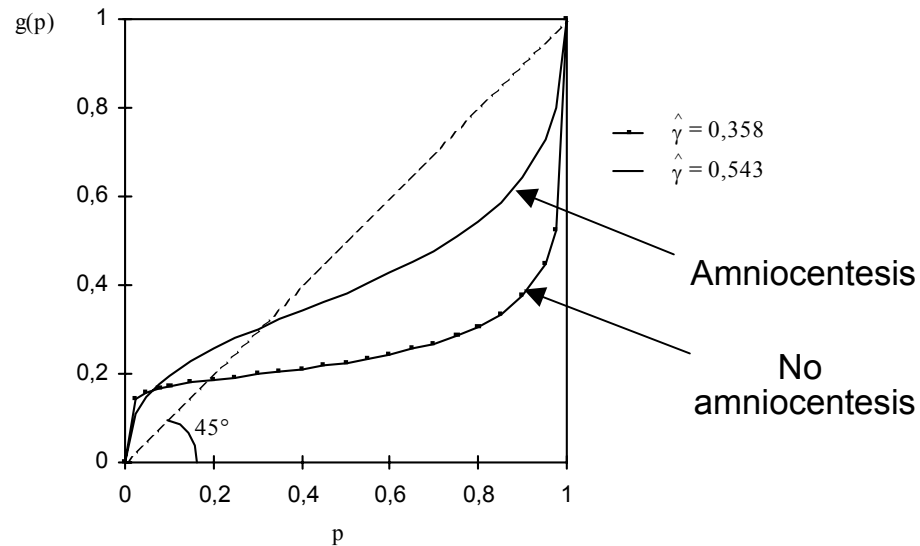
$$\Leftrightarrow \text{RDU}(\bar{A}) > \text{RDU}(A)$$

$$\gamma = \gamma_k$$

$$\gamma = \gamma_m$$

→ Results - estimation of probability weighting function

1) Inverse S-shaped



2) Median values of γ according to choices

Risk of DS	A	\bar{A}	$A \sim \bar{A}$
1:700	0.543	0.219	-
1:250	0.663	0.176	0.322
1:100	0.808	0.358	-

→ Conclusion

1) Expected Utility model

- ◆ Very low and high probabilities: Relevance of the EU model?

2) Utility values are biased

- ◆ Standard gamble method \Rightarrow Over-estimated utilities

3) Limitations of our parametric method

- ◆ γ is related to the probability distribution
- ◆ **Bias** on utilities \Rightarrow **Biased** values of γ

\Rightarrow Magnitude of the probability transformation ?