

$$\begin{array}{ccc}
 F \vee T & & T \vee F \\
 T & \& & T \\
 & & T
 \end{array}$$

Conclusion $(Raa \& Rba) \vee (Rab \& Rbb)$

$$\begin{array}{ccc}
 F \& T & & T \& F \\
 F & \vee & & F \\
 & & & F
 \end{array}$$

Exercise 4.3.1 Construct countermodels for the following invalid sequents.

- i* $\exists x Fxx \vdash \forall xy Fyx$
- ii* $\forall y \exists x Fxy \vdash \exists x Fxx$
- iii* $\forall x \exists y Fxy \vdash \exists x \forall y Fxy$
- iv* $\forall x \exists y \sim Fxy, \forall x \forall y (Gxy \rightarrow \sim Fxy) \vdash \forall x \exists y \sim Gxy$
- v* $\forall x (Fx \rightarrow \exists y Gxy) \vdash \forall x \forall y (Fx \vee \sim Gxy)$
- vi* $\forall x \exists y \forall z Vxyz \vdash \exists y \forall x \forall z Vxyz$
- vii* $\forall x \sim \forall y Txy \vdash \forall x \sim \exists y Txy$
- viii* $\exists xyz ((Fxy \& Fyz) \& \sim (Fxz \vee Fyx)) \vdash \forall x \exists y Fyx \rightarrow \forall x \sim Fxx$
- ix* $\forall x \exists y Fxy, \exists x \sim \forall y Gyx, \exists xy Fxy \leftrightarrow \exists xy (Gyx \& \sim Gxy)$
 $\vdash \exists y (Gxy \vee Gyx)$
- x* $\exists x \exists y Fxy \leftrightarrow \sim \exists x Gxx, \forall y \exists x Gyx \vdash \forall x \sim Fxx$