Reasoning about Knowledge and Beliefs

Lecture 9

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Finding out that φ

$$\mathcal{M} = \langle W, \{\sim_i\}_{i \in \mathcal{A}}, \{\preceq_i\}_{i \in \mathcal{A}}, V \rangle$$

$$\Bigg\Downarrow \ \textbf{Find out that } \varphi$$

$$\mathcal{M}' = \langle W', \{\sim'_i\}_{i \in \mathcal{A}}, \{\preceq'_i\}_{i \in \mathcal{A}}, V|_{W'} \rangle$$

Public Announcement Logic

Suppose $\mathcal{M} = \langle W, \{\sim_i\}_{i \in \mathcal{A}}, \{\preceq_i\}_{i \in \mathcal{A}}, V \rangle$ is a multi-agent Kripke Model

$$\mathcal{M}, w \models [\psi]\varphi \text{ iff } \mathcal{M}, w \models \psi \text{ implies } \mathcal{M}|_\psi, w \models \varphi$$

where $\mathcal{M}|_\psi = \langle W', \{\sim_i'\}_{i \in \mathcal{A}}, \{\preceq_i'\}_{i \in \mathcal{A}}, V' \rangle$ with

- $W' = W \cap \{w \mid \mathcal{M}, w \models \psi\}$
- For each i, $\sim_i' = \sim_i \cap (W' \times W')$
- For each i, $\preceq_i' = \preceq_i \cap (W' \times W')$
- for all $p \in \text{At}$, $V'(p) = V(p) \cap W'$

Self-Refuting Announcements

Suppose that in the College Park and Amsterdam example, the Amsterdam agent (a perfectly trustworthy source of weather information) tells the College Park agent over the phone, “You don’t know it, but it’s raining in Amsterdam”: $\neg K_b r \wedge r$.

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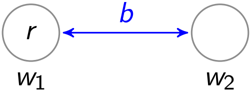

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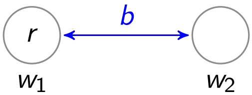

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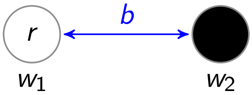

Observe that $\mathcal{M}, w_1 \vDash \langle ! \neg K_b r \wedge r \rangle \neg(\neg K_b r \wedge r)$.
Delete the world w_2 where $\neg K_b r \wedge r$ is false.

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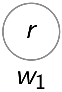

Observe that $\mathcal{M}, w_1 \models \langle ! \neg K_b r \wedge r \rangle \neg(\neg K_b r \wedge r)$.
Observe that $\mathcal{M}_{|\neg K_b r \wedge r}, w_1 \models \neg(\neg K_b r \wedge r)$.

Self-Refuting Announcements

Not only is the update with $\neg K_b r \land r$ unsuccessful in this specific case, but in general $\neg K_b r \land r$ is self-refuting. Let $\alpha := \neg K_b r \land r$.

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Proof. Suppose $\mathcal{M}, w \vDash \alpha$. In $\mathcal{M}_{|\alpha}$, there are no worlds where r is false. Hence $\mathcal{M}_{|\alpha}, w \vDash K_b r$, which means $\mathcal{M}_{|\alpha}, w \vDash \neg\alpha$. Thus, $\mathcal{M}, w \vDash [!\alpha]\neg\alpha$. Since $\mathcal{M}, w$ was arbitrary, $[!\alpha]\neg\alpha$ is valid.

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Question: is $\neg K_b \varphi \wedge \varphi$ self-refuting for all φ?

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Question: is $\neg K_b \varphi \wedge \varphi$ self-refuting for all φ?

Or is there a φ such that if you receive the true information (from a source you know to be infallible) that "you don't know it, but φ," it can *remain true* afterward that you don't know it, but φ?

What's Wrong with Moore Sentences?

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Surprisingly, this is not always the case, as we will now show...

We will show this with the **Puzzle of the Gifts** from

W. Holliday, T. Hoshi, and T. Icard. 2013

"Information Dynamics and Uniform Substitution," *Synthese*.

The Puzzle of the Gifts

With my hands behind my back, **I** walk into a room where a friend **F** is sitting. **F** did not see what if anything **I** put in my hands, and **I** know this. In fact, **I** have gifts for **F** in both hands. Instead of asking **F** to "pick a hand, any hand," **I** truthfully announce:

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1. After my announcement, does **F** know if I have a gift in my left/right/both hand(s)?
2. After my announcement, is G *true*?
3. After my announcement, does **F** *know* G?
4. If 'yes' to 2, what happens if I announce G again?

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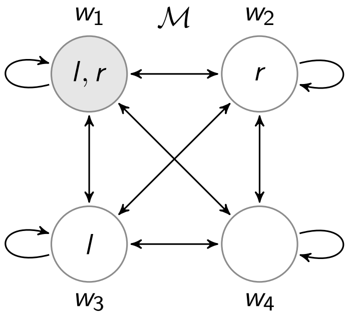

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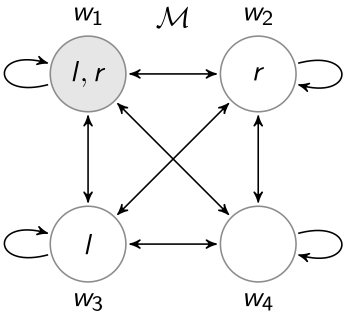

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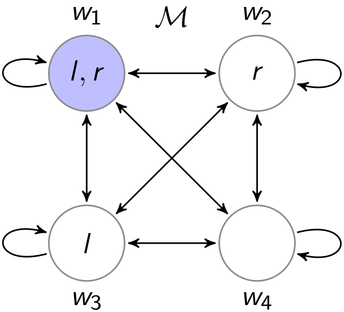

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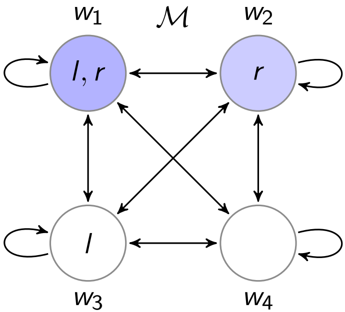

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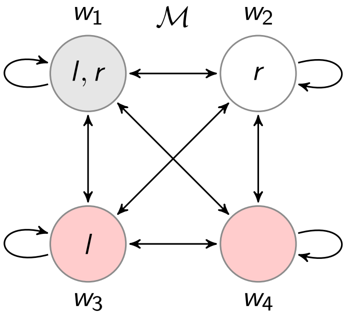

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Note: $\mathcal{M}, w_1 \vDash G$, $\mathcal{M}, w_2 \vDash G$, but $\mathcal{M}, w_3 \nvDash G$, $\mathcal{M}, w_4 \nvDash G$.

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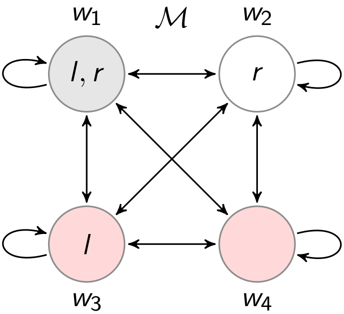

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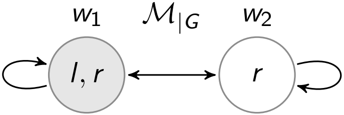

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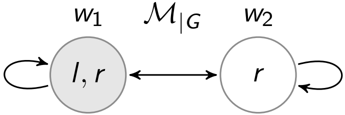

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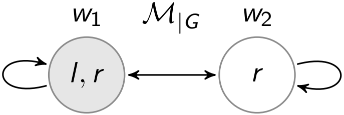

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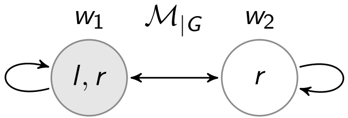

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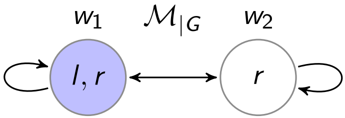

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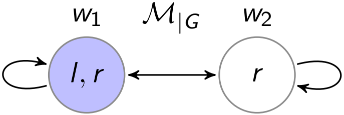

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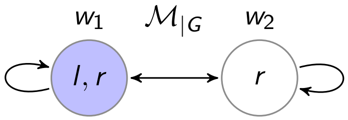

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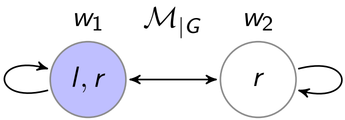

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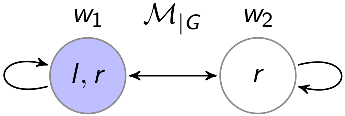

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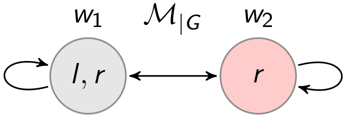
2. Is G still true? Yes. $\mathcal{M}, w_1 \models \langle !G \rangle G$.
3. Does **F** now know G?

What happens if **I** truthfully announce G, and **F** knows that **I** am an infallible source of information?



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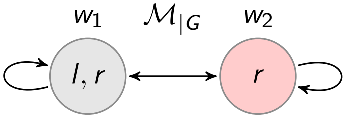

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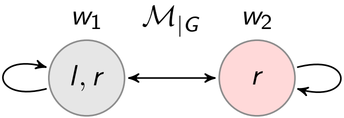

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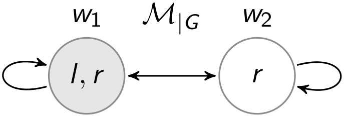

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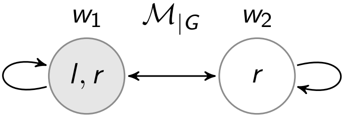

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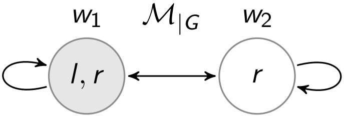

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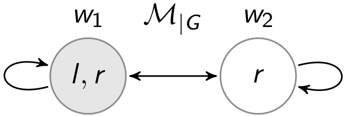
Given 2 and 3, the following is *not valid*:

$$[!\varphi]\varphi \to [!\varphi]K\varphi$$



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Given 2 and 3, the following is *not valid*:

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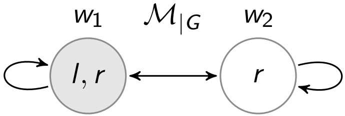
There are formulas φ such that even if φ remains true after being truly announced by a source whom you know to be infallible, you can fail to know that φ is still true.



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It follows from the answers to 2 and 3 that
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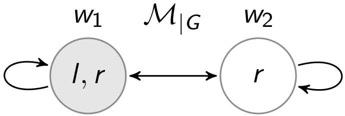

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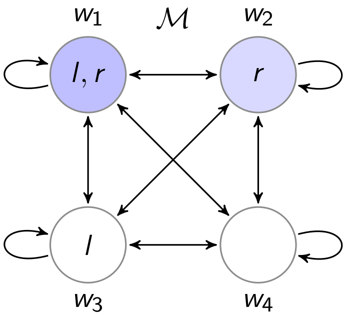
Let's check that G and $(G \wedge \neg K_{\mathbf{F}} G)$ are true at the same states in our *original* model $\mathcal{M}$, namely w_1 and w_2.

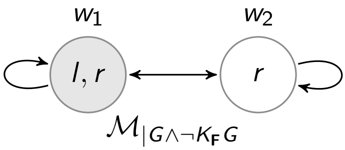
Let l be 'a gift is in the left hand' and r be 'a gift is in the right'.



We can translate G into the language of epistemic logic as

(G) $(r \wedge \neg K_{\mathbf{F}} r) \vee (l \wedge r \wedge \neg K_{\mathbf{F}} l)$.

Note: $\mathcal{M}, w_1 \vDash G \wedge \neg K_{\mathbf{F}} G$ and $\mathcal{M}, w_2 \vDash G \wedge \neg K_{\mathbf{F}} G$.



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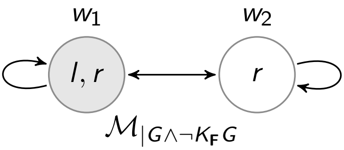
We've seen that G and $(G \wedge \neg K_{\mathbf{F}} G)$ are true at the same states in $\mathcal{M}$: w_1 and w_2.



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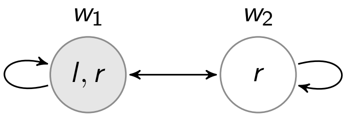

$\mathcal{M}_{|G \wedge \neg K_{\mathbf{F}} G}$

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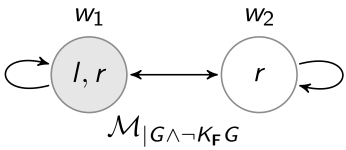
$[!\varphi \wedge \neg K\varphi]\neg(\varphi \wedge \neg K\varphi)$ is not valid for all φ.



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$[!\varphi \wedge \neg K \varphi] \neg (\varphi \wedge \neg K \varphi)$ is not valid for all φ.

Moorean utterances are not always self-refuting.

What's Wrong with Moore Sentences?

Is there a φ such that if you receive the true information (from a source you know to be infallible) that "you don't know it, but φ," it can *remain true* afterward that you don't know it, but φ?

> If you know that I am well informed and if I address the words . . . to you, these words have a curious effect which may perhaps be called anti-performatory. You may come to know that what I say *was* true, but saying it in so many words has the effect of making what is being said false. (68-69)

J. Hintikka 1962. *Knowledge and Belief*.

Surprisingly, this is not always the case, as we just showed.