Artifactual Functions: A Plan for Analysis

Jesse Hughes

JHughes@tm.tue.nl

Technical University of Eindhoven

Norms in Knowledge

An epistemological investigation.

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

- Prescriptive knowledge — what one ought to do

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

- Prescriptive knowledge — what one ought to do
- Functional knowledge — how things ought to perform

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

- Prescriptive knowledge — what one ought to do
- Functional knowledge — how things ought to perform

Restrict to a familiar domain: technical artifacts

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

- Prescriptive knowledge — guides, rules and advice for designing and making artifacts
- Functional knowledge — how things ought to perform

Restrict to a familiar domain: technical artifacts

Norms in Knowledge

An epistemological investigation.

Most epistemology deals with descriptive claims.

We aim to investigate knowledge of (non-moral) normative claims.

- Prescriptive knowledge — guides, rules and advice for designing and making artifacts
- Functional knowledge — functions of technical artifacts

Restrict to a familiar domain: technical artifacts

Functions

Some things have functions, purposes, intended uses, …

Functions

Some things have functions, purposes, intended uses, . . .

Functional ascriptions:

- "The function of the heart is to pump blood."

Functions

Some things have functions, purposes, intended uses, …

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”

Functions

Some things have functions, purposes, intended uses, . . .

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”
- “The subroutine (is intended to) ensure that the user is authorized.”

Functions

Some things have functions, purposes, intended uses, …

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”
- “The subroutine (is intended to) ensure that the user is authorized.”
- “The magician’s assistant is for distracting the audience.”

Functions

Some things have functions, purposes, intended uses, . . .

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”
- “The subroutine (is intended to) ensure that the user is authorized.”
- “The magician’s assistant is for distracting the audience.”

We ascribe functions to biological stuff,

Functions

Some things have functions, purposes, intended uses, …

Functional ascriptions:

- "The function of the heart is to pump blood."
- "That switch mutes the television."
- "The subroutine (is intended to) ensure that the user is authorized."
- "The magician's assistant is for distracting the audience."

We ascribe functions to biological stuff, artifacts,

Functions

Some things have functions, purposes, intended uses, . . .

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”
- “The subroutine (is intended to) ensure that the user is authorized.”
- “The magician’s assistant is for distracting the audience.”

We ascribe functions to biological stuff, artifacts, algorithms,

Functions

Some things have functions, purposes, intended uses, . . .

Functional ascriptions:

- “The function of the heart is to pump blood.”
- “That switch mutes the television.”
- “The subroutine (is intended to) ensure that the user is authorized.”
- “The magician’s assistant is for distracting the audience.”

We ascribe functions to biological stuff, artifacts, algorithms, personal roles.

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Artifactual functions arise from intentions.

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Artifactual functions arise from intentions.

Biological functions must appeal to history, propensity, something else?

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Artifactual functions arise from intentions.

Biological functions must appeal to history, propensity, something else?

Nonetheless, some theorists include artifactual functions in a biological function theory.

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Artifactual functions arise from intentions.

Biological functions must appeal to history, propensity, something else?

Nonetheless, some theorists include artifactual functions in a biological function theory.

Question: Are these functions instances of a single coherent concept?

Function *simpliciter*?

Biological functions have generated considerable interest and controversy.

Artifactual functions arise from intentions.

Biological functions must appeal to history, propensity, something else?

Nonetheless, some theorists include artifactual functions in a biological function theory.

Question: Are these functions instances of a single coherent concept?

Answer: Er, um, …oh look! Isn't that the queen?

Artifactual function

Artifactual functions come in three different flavors.

Artifactual function

Artifactual functions come in three different flavors.

- Accidental function

Artifactual function

Artifactual functions come in three different flavors.

- Accidental function
- Repeated use function

Artifactual function

Artifactual functions come in three different flavors.

- Accidental function
- Repeated use function
- Designed function

Artifactual function

Artifactual functions come in three different flavors.

- Accidental function
- Repeated use function
- Designed function

These functions are distinguished by history,

Artifactual function

Artifactual functions come in three different flavors.

- Accidental function
- Repeated use function
- Designed function

These functions are distinguished by history,
expectations,

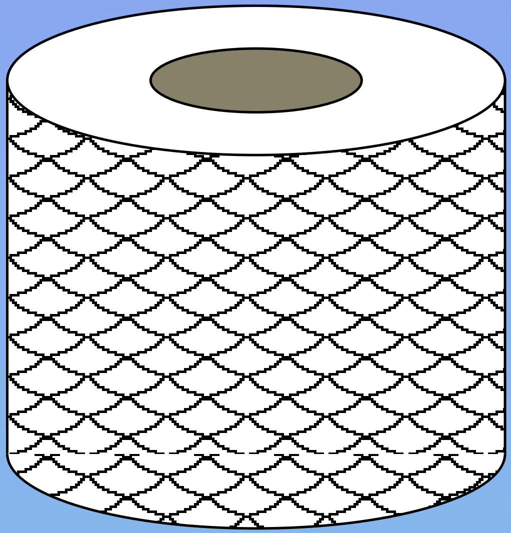
Artifactual function

Artifactual functions come in three different flavors.

- Accidental function
- Repeated use function
- Designed function

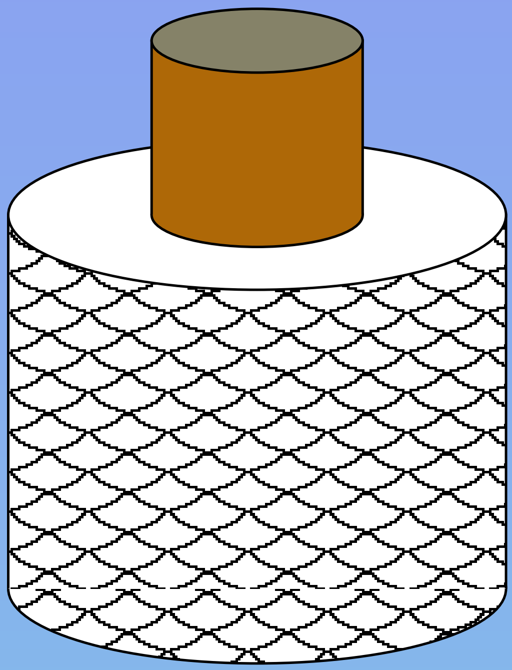
These functions are distinguished by history, expectations, normative features.

A very serious example.



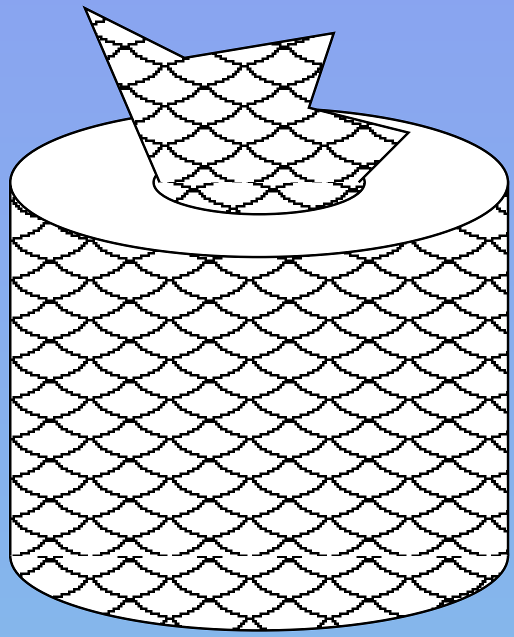
Facial tissue is more expensive than toilet paper.

A very serious example.



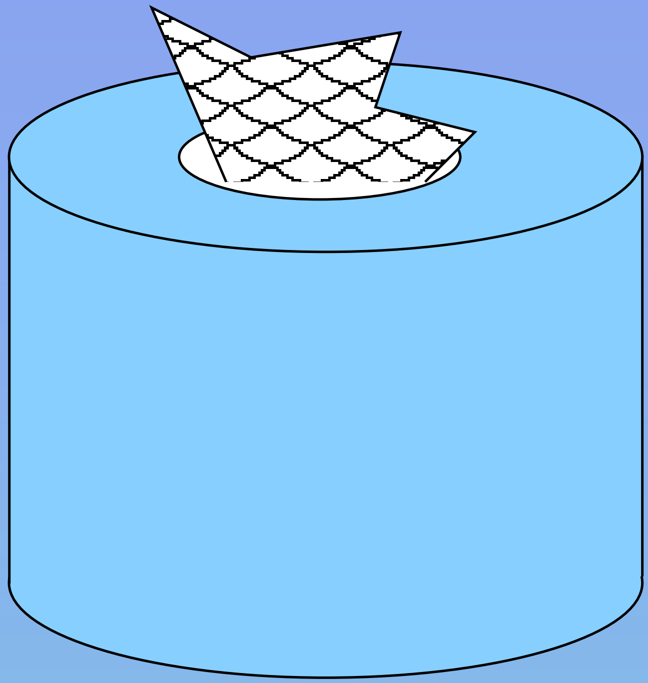
Step one: remove the center piece.

A very serious example.



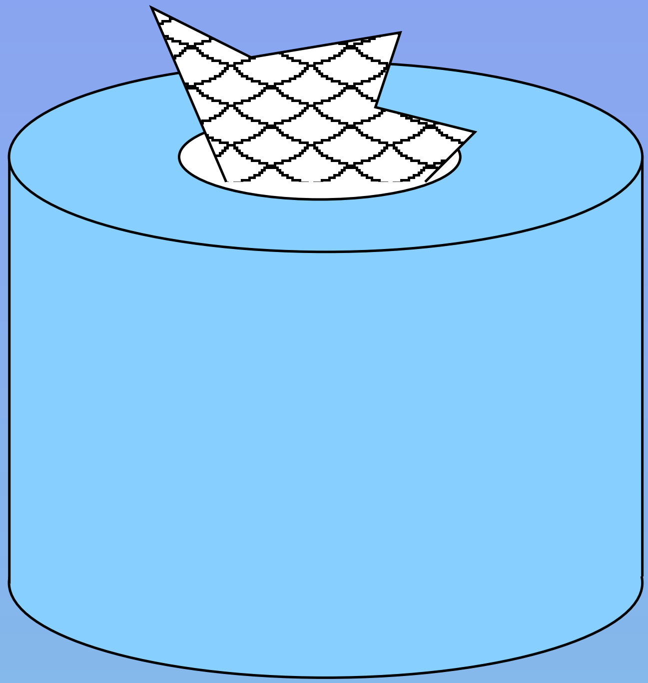
Step two: Dispense tissue via vacant center.

A very serious example.



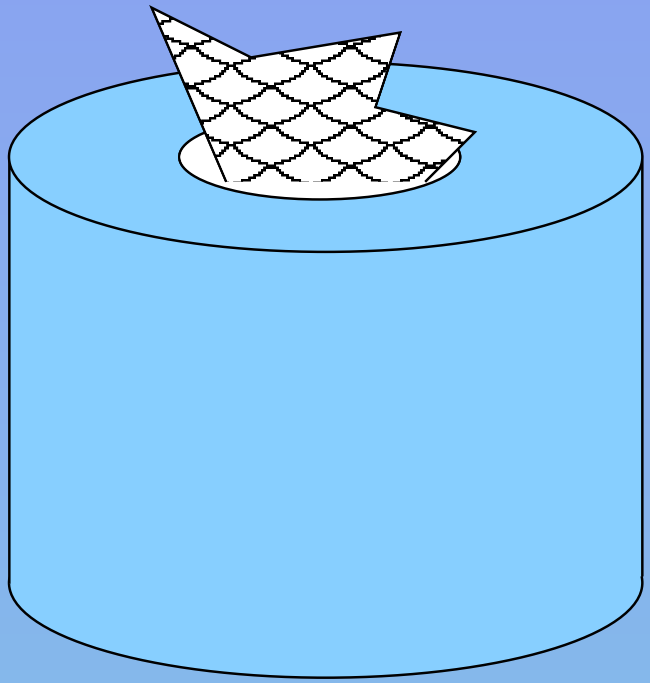
Decorative covers: that Martha Stewart touch.

A very serious example.



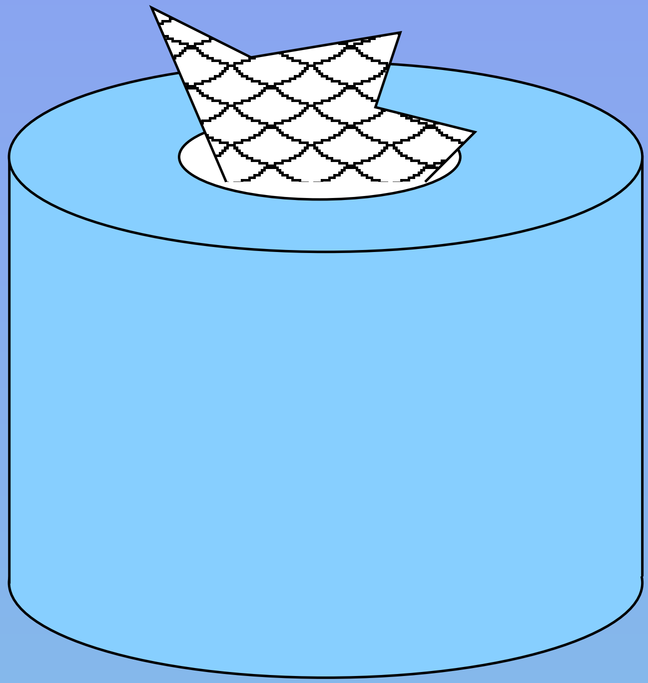
This alternate function arose first as an accidental function.

A very serious example.



It became an example of repeated use function (with designed accessories).

A very serious example.



Now coreless rolls of toilet paper are available (i.e., designed function).

Accidental functions

We regard accidental function as the simplest sort.

Accidental functions

We regard accidental function as the simplest sort.

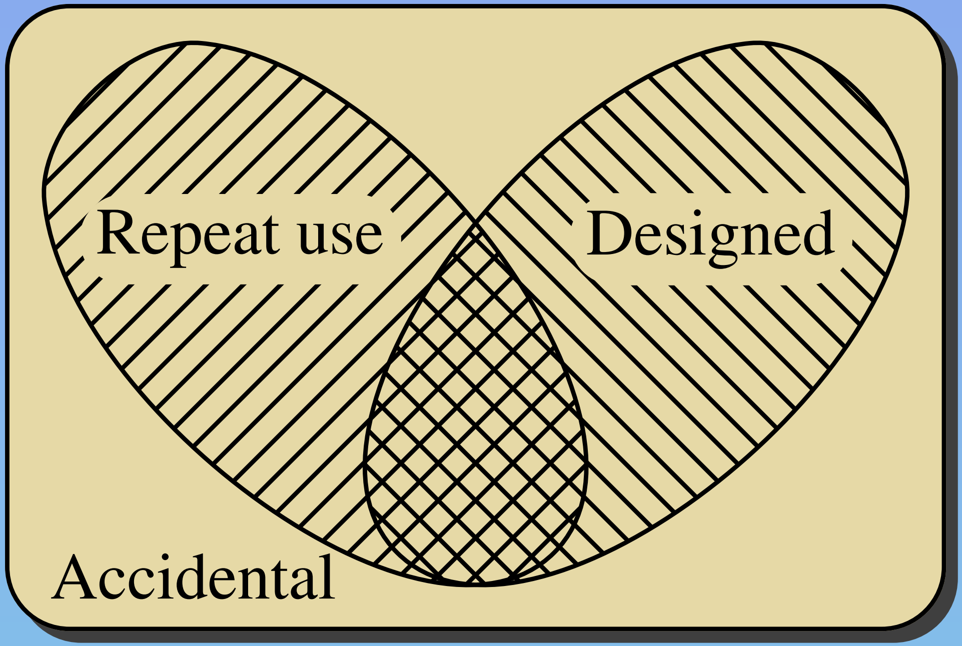
An artifact a has the accidental function f if a can be used to do f.

Accidental functions

We regard accidental function as the simplest sort.

An artifact a has the accidental function f if a can be used to do f.

We expect:

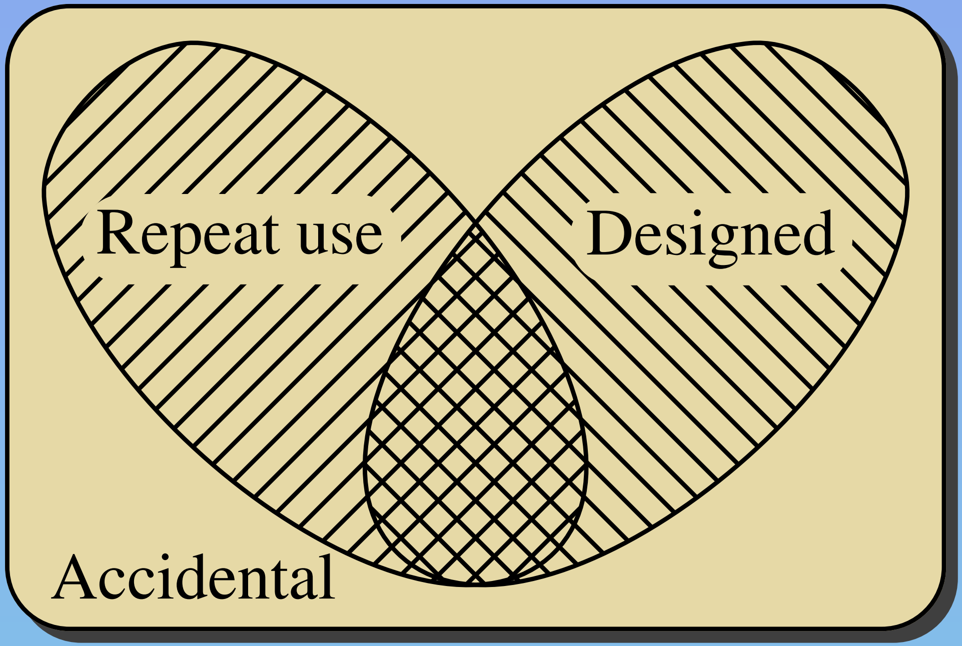


Accidental functions

We regard accidental function as the simplest sort.

An artifact a has the accidental function f if a can be used to do f.

We expect:



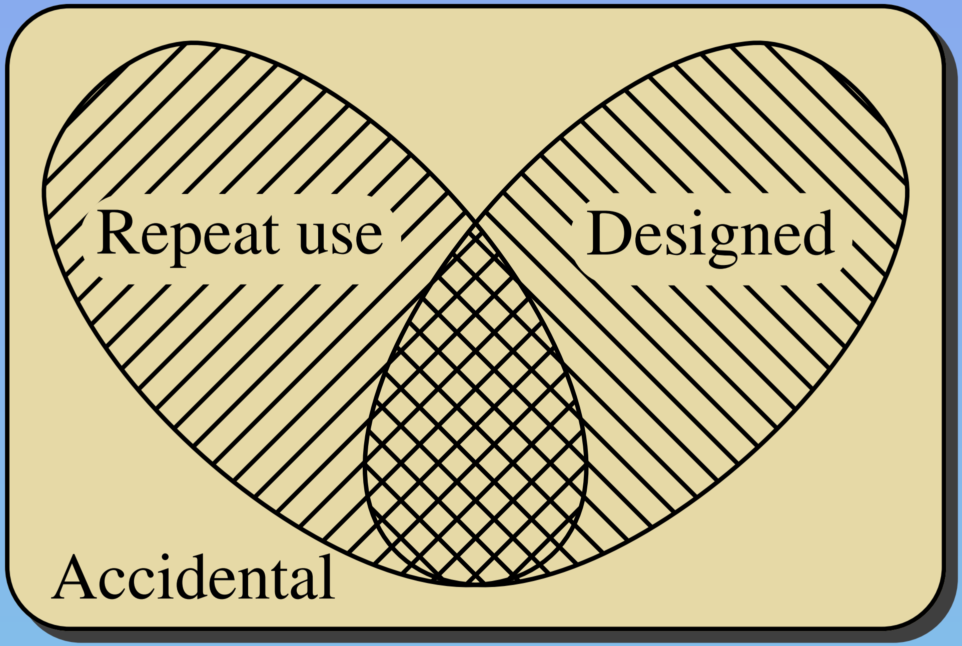
What we say about accidental functions apply to repeated use and designed functions, too.

Accidental functions

We regard accidental function as the simplest sort.

An artifact a has the accidental function f if a can be used to do f.

We expect:



What we say about accidental functions apply to repeated use and designed functions, too.

(We hope.)

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

> An artifact a has the accidental function f if a can be used to do f.

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

An artifact a has the accidental function f if there is a means to f involving a.

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

An artifact a has the accidental function f if there is a means to f involving a.

First step: analyze means-end ascriptions.

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

> An artifact a has the accidental function f if there is a means to f involving a.

First step: analyze means-end ascriptions.

Aim: conceptual analysis, not tools for practical reasoning.

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

> An artifact a has the accidental function f if there is a means to f involving a.

First step: analyze means-end ascriptions.

Aim: conceptual analysis, not tools for practical reasoning.

What does a means-end claim mean?

Means and Ends

Whatever an accidental function is, it includes a means-end claim.

> An artifact a has the accidental function f if there is a means to f involving a.

First step: analyze means-end ascriptions.

Aim: conceptual analysis, not tools for practical reasoning.

What does a means-end claim mean?

Procedure: analysis via formalization.

The Proposed Development

Means-end ascriptions

- Provide formal semantics for means-end ascriptions.

The Proposed Development

Means-end ascriptions ⇒ Accidental functions

- Provide formal semantics for means-end ascriptions.
- Include artifacts and users.

The Proposed Development

Means-end ascriptions $\Rightarrow$ Accidental functions $\Rightarrow$ Other functions

- Provide formal semantics for means-end ascriptions.
- Include artifacts and users.
- Additional norms involved?

The Proposed Development

Means-end ascriptions ⇒ Accidental functions ⇒ Other functions ⇒ Function *simpliciter*?

- Provide formal semantics for means-end ascriptions.
- Include artifacts and users.
- Additional norms involved?
- Who knows?

The Proposed Development

Means-end ascriptions ⇒ Accidental functions ⇒ Other functions ⇒ Function *simpliciter*?

- Provide formal semantics for means-end ascriptions.
- Include artifacts and users.
- Additional norms involved?
- Who knows?

Today, we restrict our attention to means-end ascriptions.

Dynamic components

m is a means to the end φ.

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.
Dynamic logic is an appropriate setting for us.

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.
Dynamic logic is an appropriate setting for us.

act actions $m, n, \ldots$

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.
Dynamic logic is an appropriate setting for us.

act	actions	$m, n, \ldots$
prop	atomic propositions	$P, Q, \ldots$

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.
Dynamic logic is an appropriate setting for us.

act	actions	$m, n, \ldots$
prop	atomic propositions	$P, Q, \ldots$
ME	all propositions	$\varphi, \psi, \ldots$

Dynamic components

m is a means to the end φ.

m is an action, the result of which is (likely) φ.
φ is a condition, i.e., a formula.
Dynamic logic is an appropriate setting for us.

act	actions	$m, n, \ldots$
prop	atomic propositions	$P, Q, \ldots$
ME	all propositions	$\varphi, \psi, \ldots$

$$\mathbf{ME} \rightarrow \mathbf{prop} \mid \neg\,\mathbf{ME} \mid \mathbf{ME} \wedge \mathbf{ME} \mid [\mathbf{act}]\,\mathbf{ME}$$

Dynamic operators

We interpret $[m]\varphi$ as: *After doing m, the condition φ holds/is likely.*

Dynamic operators

We interpret $[m]\varphi$ as: *After doing m, the condition φ holds/is likely.*

Dynamic logic interprets actions as transitions between worlds.

Dynamic operators

We interpret $[m]\varphi$ as: *After doing m, the condition φ holds/is likely.*

Dynamic logic interprets actions as transitions between worlds.

m is a means to φ iff doing m changes the world so that φ.

Dynamic operators

We interpret $[m]\varphi$ as: *After doing m, the condition φ holds/is likely.*

Dynamic logic interprets actions as transitions between worlds.

m is a means to φ iff doing m changes the world so that φ.

m is a means to φ in world w iff $w \models [m]\varphi$

Dynamic operators

We interpret $[m]\varphi$ as: *After doing m, the condition φ holds/is likely.*

Dynamic logic interprets actions as transitions between worlds.

m is a means to φ iff doing m changes the world so that φ.

m is a means to φ in world w iff $w \models [m]\varphi$

But this is a bit too simple…

Conditional components

Means/end attributions come with (implicit) preconditions.

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race…

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race. . . but only if there are bullets in the pistol.

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race… but only if there are bullets in the pistol.

Formally:

$$\mathbf{Loaded} \Rightarrow [\mathrm{fire}]\mathbf{Race}$$

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race... but only if there are bullets in the pistol.

Formally:

$$\mathbf{Loaded} \Rightarrow [\mathrm{fire}]\mathbf{Race}$$

Clearly, $\Rightarrow$ is not material implication.

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race... but only if there are bullets in the pistol.

Formally:

$$\textbf{Loaded} \Rightarrow [\text{fire}]\textbf{Race}$$

Clearly, $\Rightarrow$ is not material implication.

It is evidently not monotone:

$$\neg((\textbf{Loaded} \wedge \textbf{RunnersDeaf}) \Rightarrow [\text{fire}]\textbf{Race})$$

Conditional components

Means/end attributions come with (implicit) preconditions.

Firing the starter pistol will start the race... but only if there are bullets in the pistol.

Formally:

$$\mathbf{Loaded} \Rightarrow [\mathrm{fire}]\mathbf{Race}$$

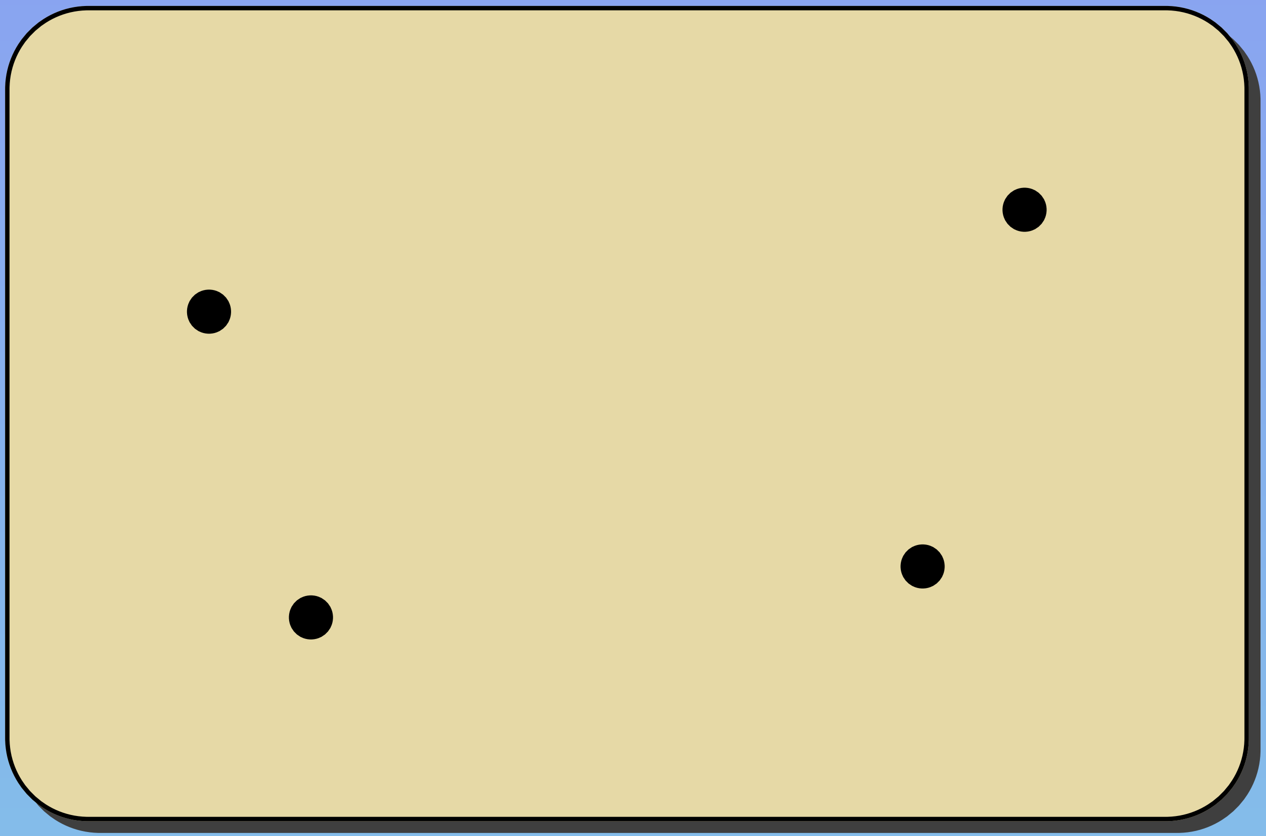
Clearly, $\Rightarrow$ is not material implication.

It is evidently not monotone:

$$\neg((\mathbf{Loaded} \wedge \mathbf{RunnersDeaf}) \Rightarrow [\mathrm{fire}]\mathbf{Race})$$

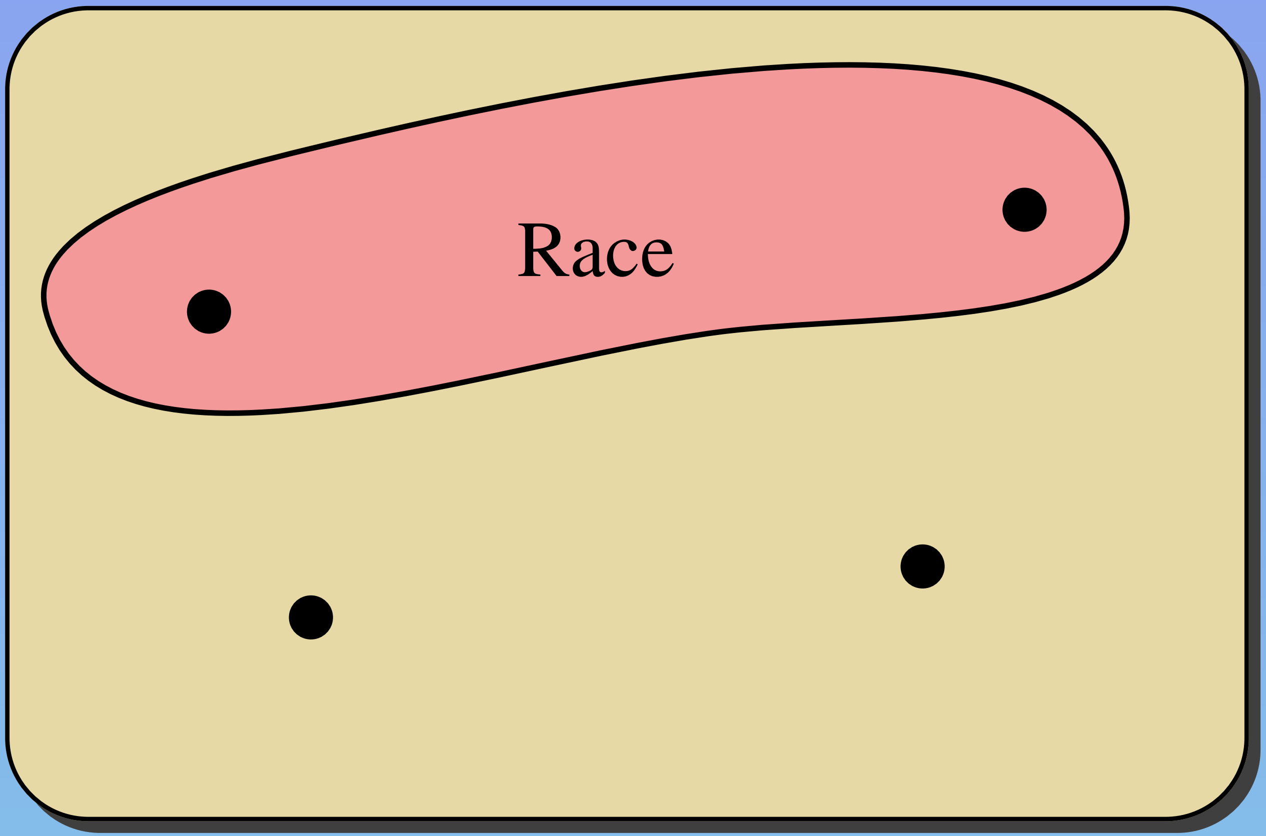
We will ignore $\Rightarrow$ hereafter.

Dynamic semantics



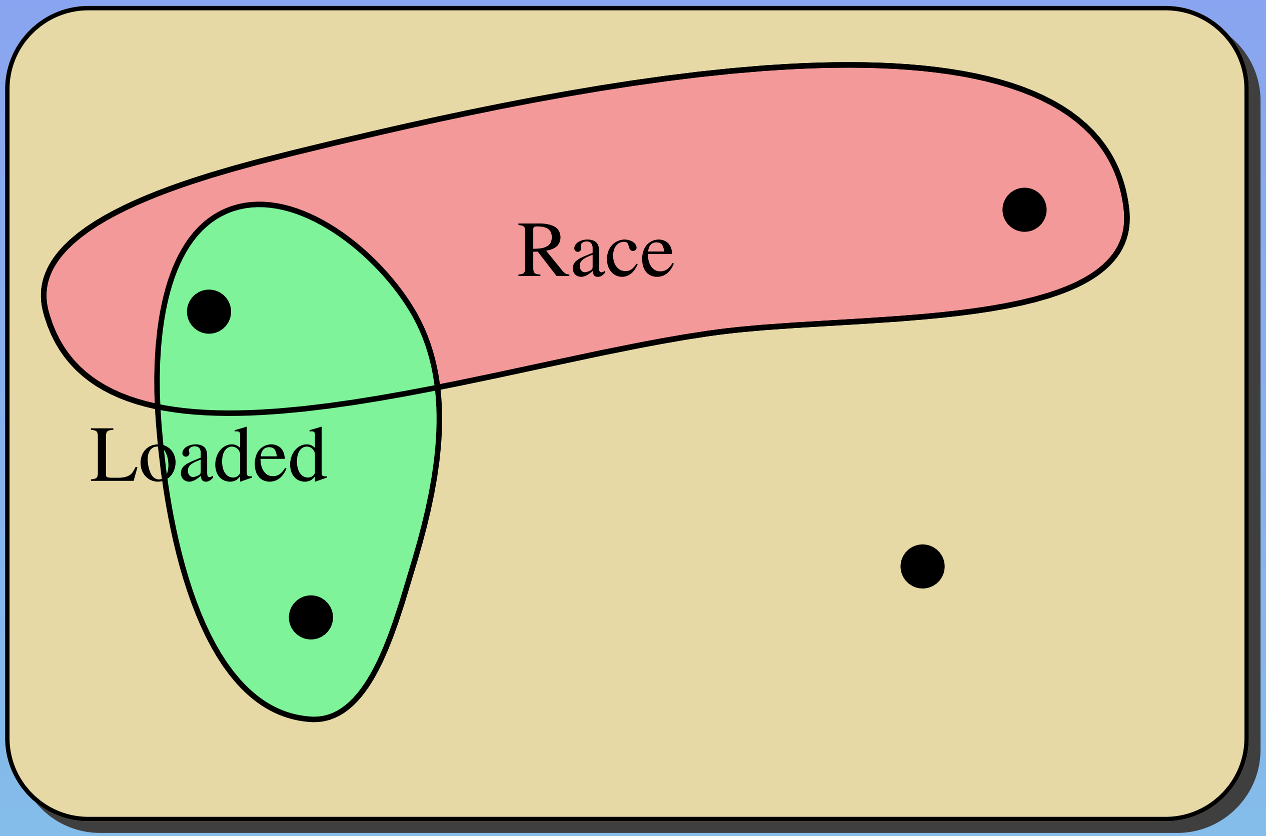
A simple model.

Dynamic semantics



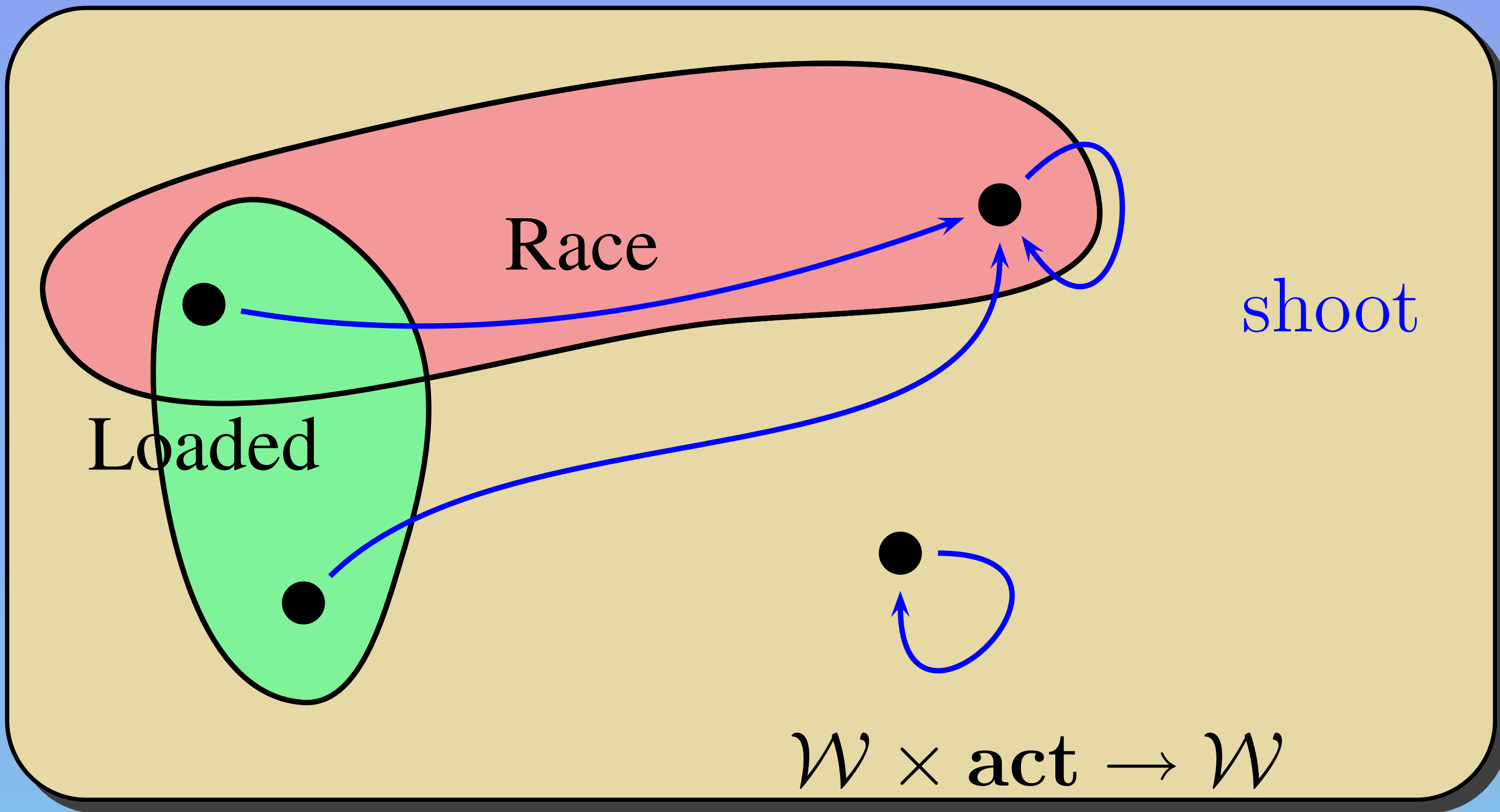
Worlds in which the race has started. . .

Dynamic semantics



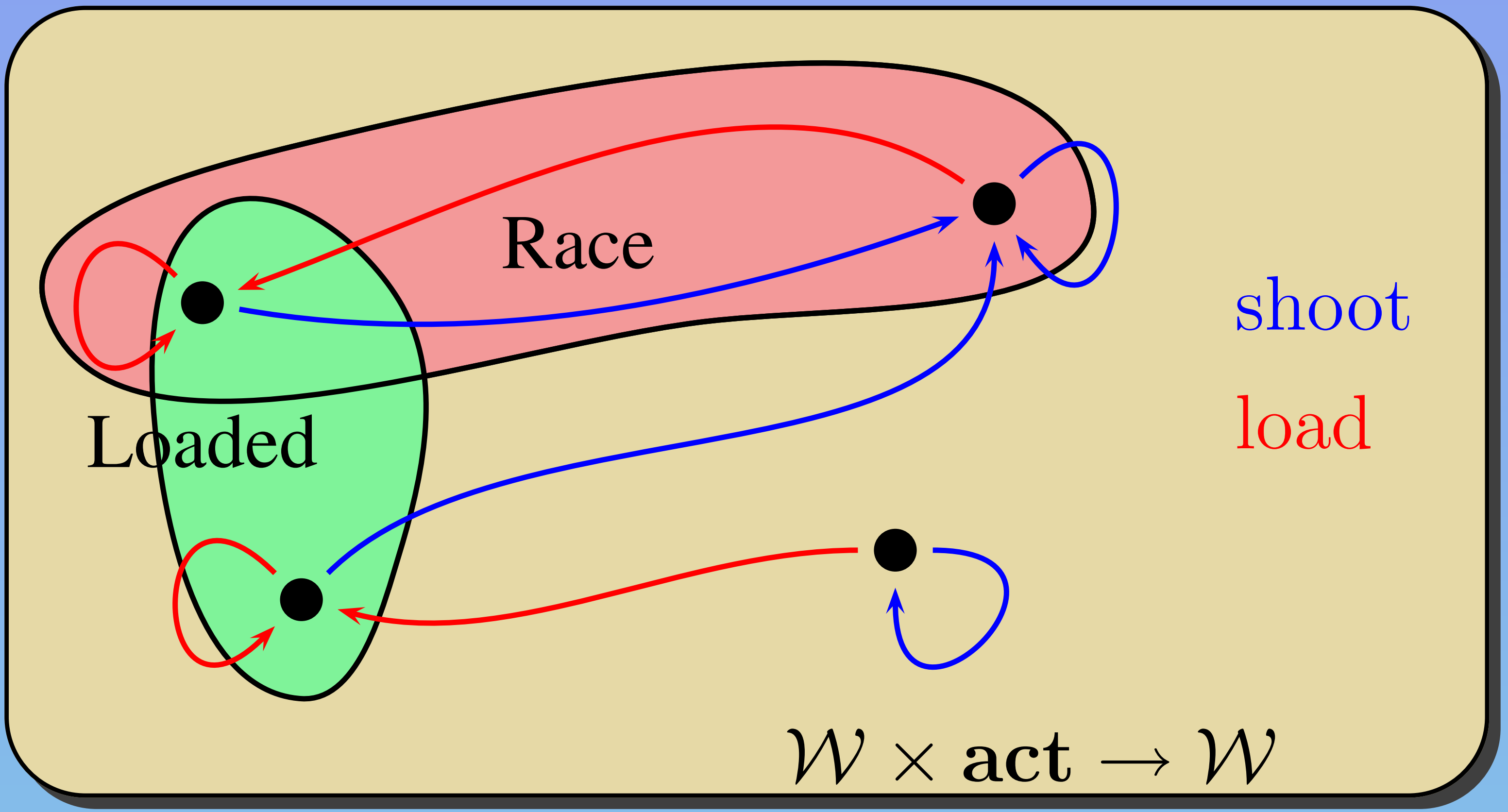
and those in which the gun is loaded.

Dynamic semantics



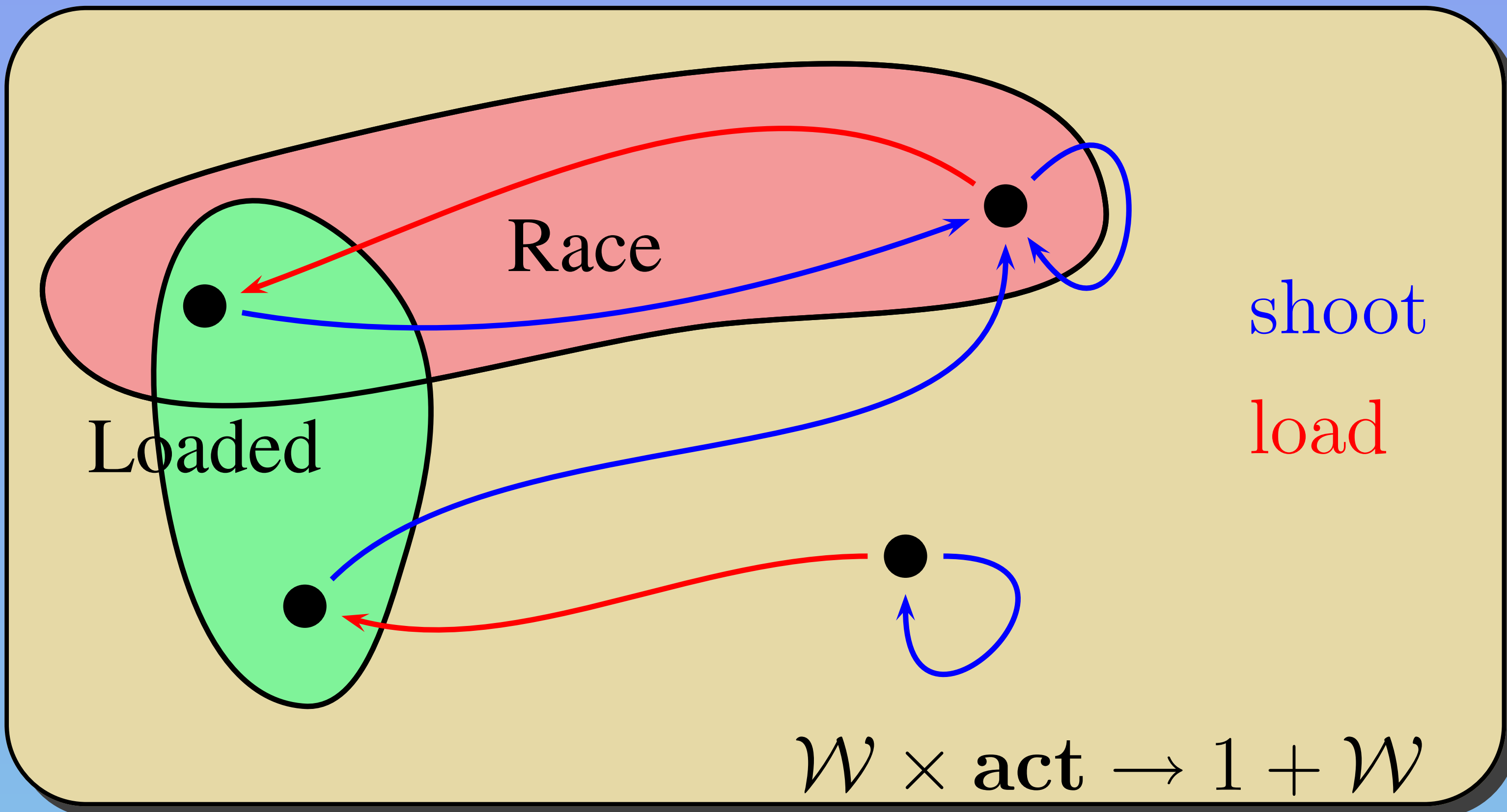
The transition structure for shoot…

Dynamic semantics



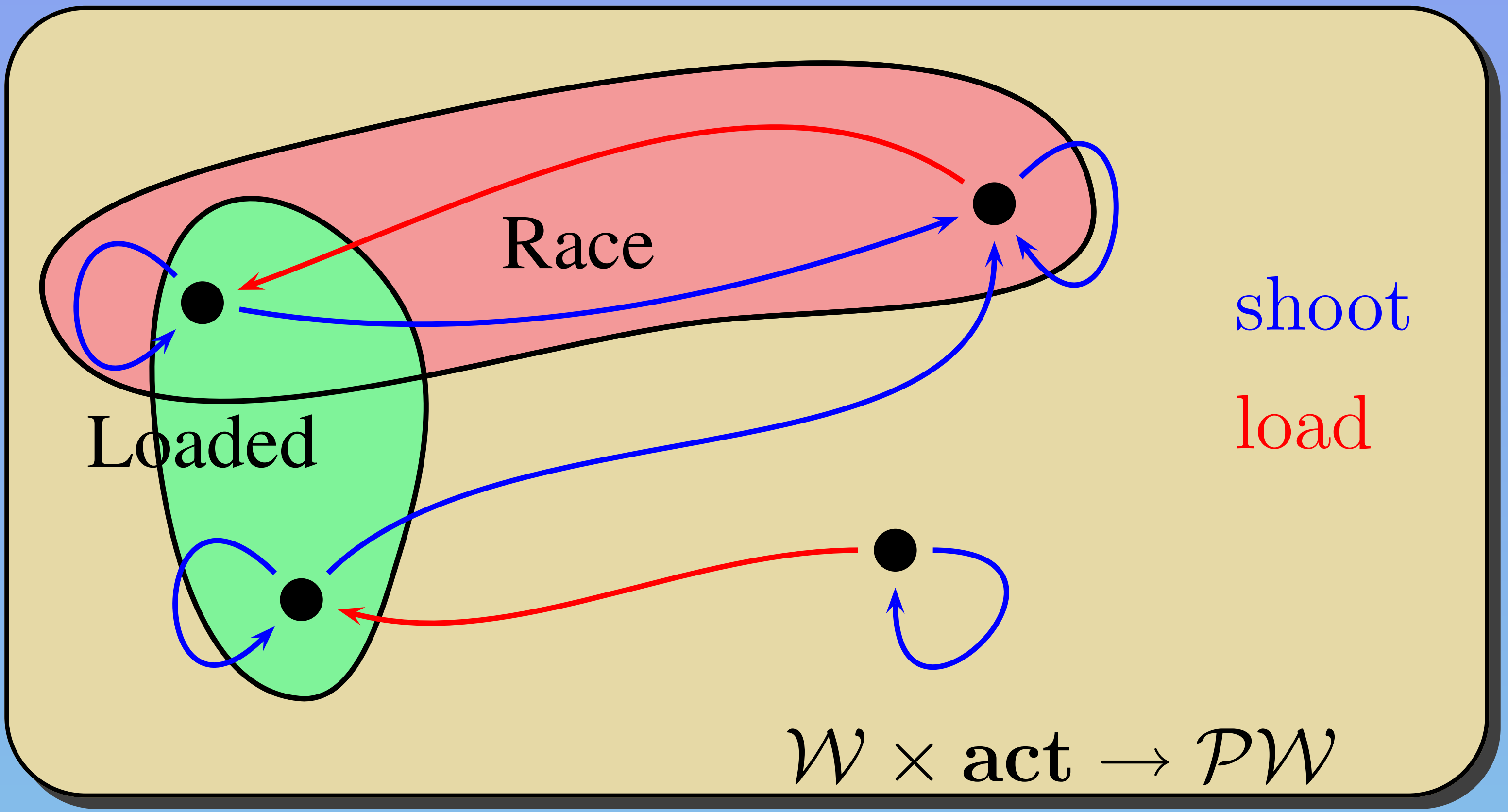
and the structure for load.

Dynamic semantics



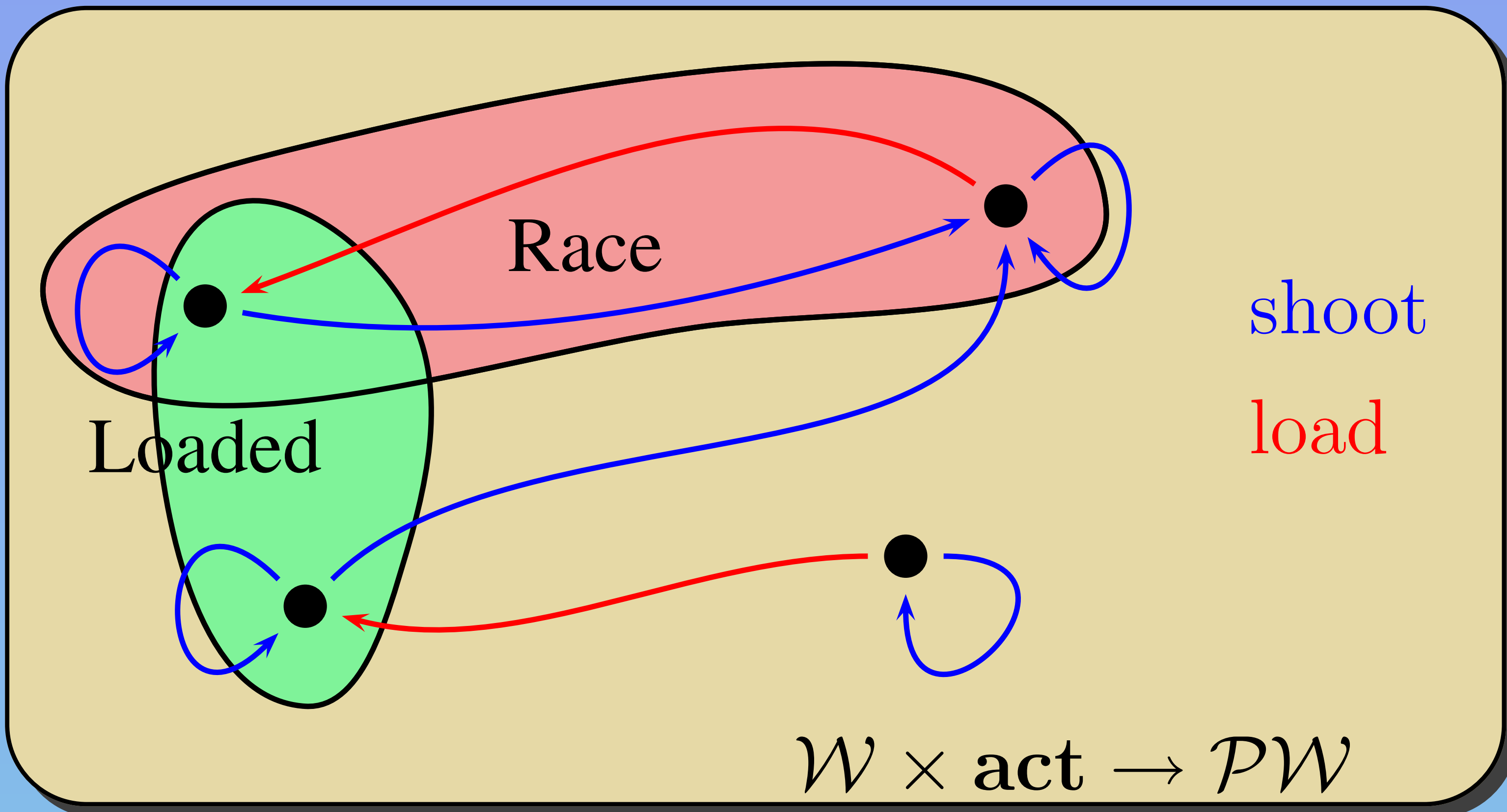
Maybe not every action can be performed in every state.
(You can't load a loaded gun.)

Dynamic semantics



Or maybe outcomes are not determined (say, a gun can jam).

Dynamic semantics



But a jam is less likely than a successful shot. Our semantics should reflect this fact.

Likelihood semantics

A likelihood model has a transition structure

$$\mathcal{W} \times \mathbf{act} \to \mathcal{D}(\mathcal{W}),$$

where $\mathcal{D}(\mathcal{W})$ is the set of discrete distributions on $\mathcal{W}$.

Likelihood semantics

A likelihood model has a transition structure

$$\mathcal{W} \times \mathbf{act} \to \mathcal{D}(\mathcal{W}),$$

where $\mathcal{D}(\mathcal{W})$ is the set of discrete distributions on $\mathcal{W}$.

We define a likelihood function

$$l : \mathcal{W} \times \mathbf{ME} \to [0, 1].$$

Likelihood semantics

A likelihood model has a transition structure

$$\mathcal{W} \times \textbf{act} \to \mathcal{D}(\mathcal{W}),$$

where $\mathcal{D}(\mathcal{W})$ is the set of discrete distributions on $\mathcal{W}$.
We define a likelihood function

$$l : \mathcal{W} \times \textbf{ME} \to [0, 1].$$

Fixing $\alpha \in [\frac{1}{2}, 1]$, we write

$$w \models \varphi \quad \Leftrightarrow \quad l(w, \varphi) \geq \alpha$$

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

As long as m is likely enough to yield φ and n likely enough to yield ψ, then

$$w \models [m]\varphi \wedge [n]\psi.$$

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

As long as m is likely enough to yield φ and n likely enough to yield ψ, then

$$w \models [m]\varphi \wedge [n]\psi.$$

This is perhaps controversial. Certainly, our likelihood functions are not probability distributions.

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

Now what if $m = n$? We offer two alternatives.

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

Now what if $m = n$? We offer two alternatives.

Simple semantics:
$l(w, [m]\varphi \wedge [m]\psi) = \min\{l(w, [m]\varphi), l(w, [m]\psi)\}.$

Likelihood functions

For actions $m \neq n$, we require

$$l(w, [m]\varphi \wedge [n]\psi) = \min\{l(w, [m]\varphi), l(w, [n]\psi)\}.$$

Now what if $m = n$? We offer two alternatives.

Simple semantics:
$l(w, [m]\varphi \wedge [m]\psi) = \min\{l(w, [m]\varphi), l(w, [m]\psi)\}$.
Distributive semantics:
$l(w, [m]\varphi \wedge [m]\psi) = l(w, [m](\varphi \wedge \psi))$.

Comparison

	Propositional
Simple semantics	👍
Distributive semantics	👍

For every purely propositional φ, we have $l(w, \varphi) \in \{0, 1\}$.

Comparison

	Propositional	Motivation
Simple semantics	👍	👍
Distributive semantics	👍	👎

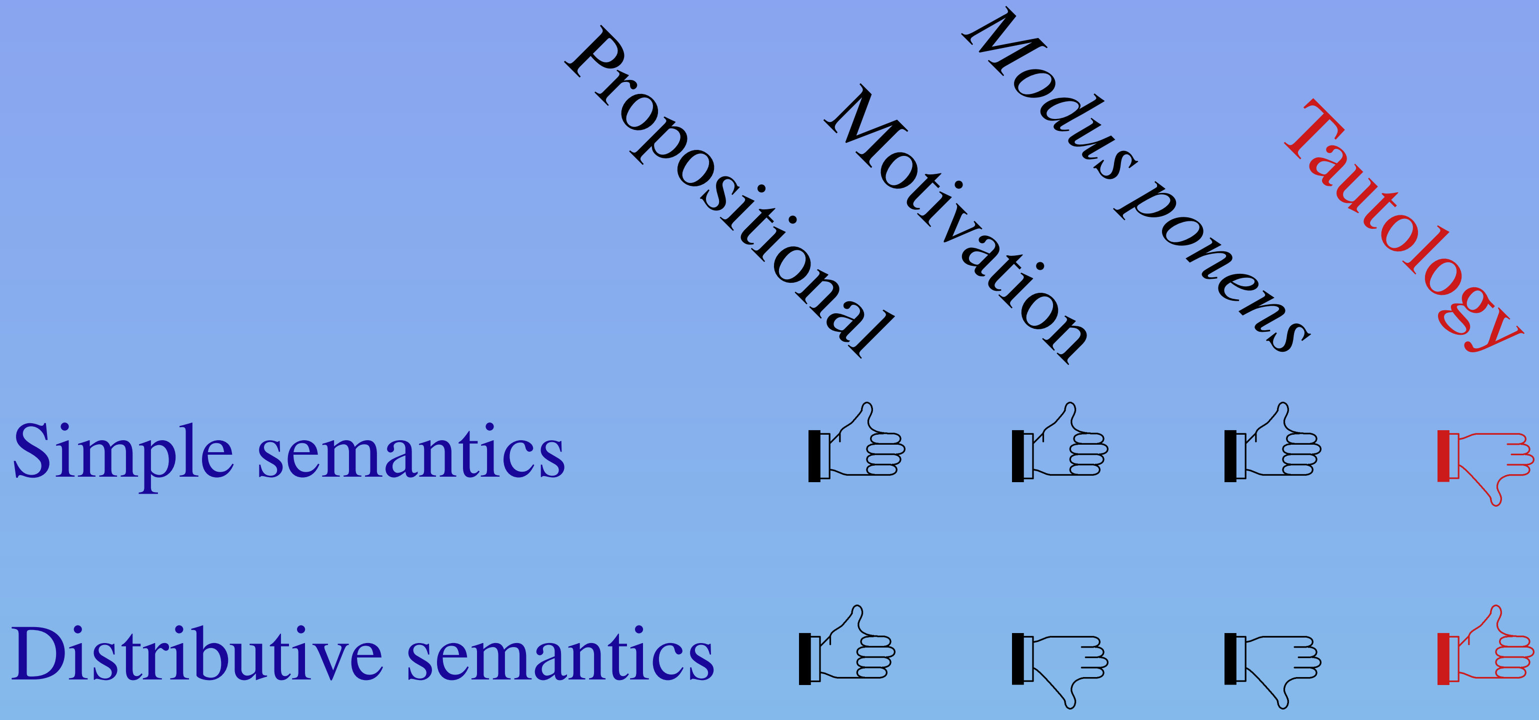
A simple and compelling argument that the semantics are the right semantics.

Comparison

	Propositional	Motivation	*Modus ponens*
Simple semantics	👍	👍	👍
Distributive semantics	👍	👎	👎

If $w \models \varphi \rightarrow \psi$ and $w \models \varphi$, then $w \models \psi$.

Comparison



For every tautology φ, we have $l(w, \varphi) = 1$.

Comparison

	Propositional	Motivation	Modus ponens	Tautology	Equivalence
Simple semantics	👍	👍	👍	👎	👎
Distributive semantics	👍	👎	👎	👍	👍

Whenever $\vdash \varphi \leftrightarrow \psi$, we have $l(w, \varphi) = l(w, \psi)$.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:
- Two semantics for dynamic logic with likelihoods.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:
- Two semantics for dynamic logic with likelihoods.

To do:

- Final word on likelihoods?

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:
- Two semantics for dynamic logic with likelihoods.

To do:

- Final word on likelihoods?
- Introduce artifacts & actors in dynamic logic.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:
- Two semantics for dynamic logic with likelihoods.

To do:

- Final word on likelihoods?
- Introduce artifacts & actors in dynamic logic.
- Investigate stronger norms in repeated use & designed functions.

Concluding remarks

Progress:

- A broad strategy for analyzing functions.
- A syntax for means-end ascriptions.
- Several semantic options for same, including:
- Two semantics for dynamic logic with likelihoods.

To do:

- Final word on likelihoods?
- Introduce artifacts & actors in dynamic logic.
- Investigate stronger norms in repeated use & designed functions.
- A million things not listed here.