Picture Descriptions and Centered Content

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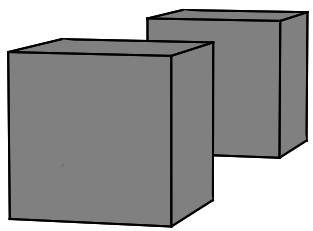
Possible worlds semantics for sentences

$[\![\text{there are two cubes}]\!] = \textit{set of possible situations}$

Possible worlds semantics for sentences

⟦there are two cubes⟧ = *set of possible situations*

⟦  ⟧ = *set of possible situations*

Recent literature on it

Greenberg, Gabriel. 2011. The semiotic spectrum. Rutgers PhD. dissertation.

Abusch, Dorit. 2012. Applying discourse semantics and pragmatics to co-reference in picture sequences. Sinn und Bedeutung 17.

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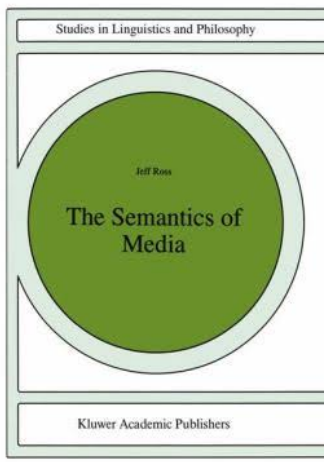
Interest in comparing and contrasting semantics of natural language with semantics of pictures and pictorial narratives.

In the picture, there is a cube in front of an octahedron.

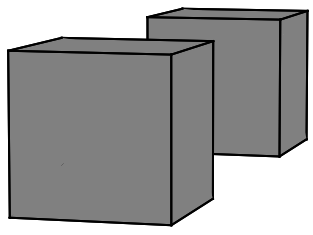
Jeff Ross 1997. *Semantics of Media*.



Semantics for pictures

WANT TO GET TO ...

$$[\![\ \ \ ]\!] = \textit{set of possible situations}$$



Rendering

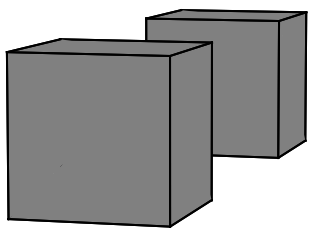
Given a description of a possible world as a data structure ...

Possible world w_1

type	*scale*	*translation*	*rotation*
cube	1.0	[0,0,0]	[0,0,0]
cube	1.0	[3,0,0]	[0,0,0]

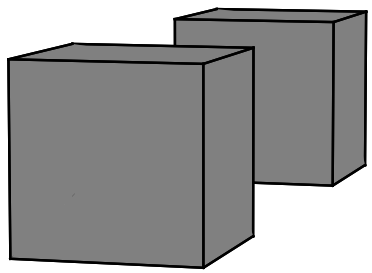
... and a specification of a viewpoint—an oriented location,

... compute a picture.



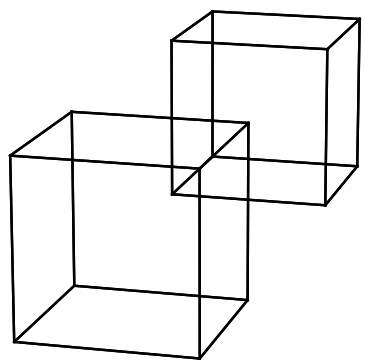
Marking rule

Mark a point in the picture plane black if the projection line from the viewpoint through that point intersects the edge of an object before it intersects any other part of an object, otherwise in gray if it intersects some object, and otherwise in white.



Marking rule for line drawing

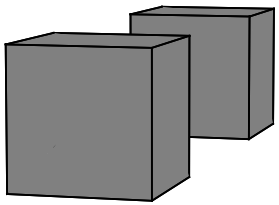
Mark a point of the picture plane in black if the directed projection line intersects the edge of an object, and otherwise in white.



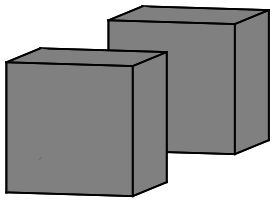
Call the marking parameter M.

Projection line parameter

Converging projection lines result in perspective picture.



Parallel projection lines result in orthographic picture.



Call the projection line parameter G.

Propositional semantic value

Render a world w to a picture given v, M and G.

$$p = \Pi(w, v, M, G)$$

Invert rendering to find the propositional semantic value of picture p.

$$[\![p]\!]^{M,G} = \{w | \exists v. p = \Pi(w, v, M, G)\}$$

Viewpoint-centered semantic value

... is set of pairs of a world and a viewpoint.

$$[\![p]\!]^{M,G} = \{\langle w, v\rangle | p = \Pi(w, v, M, G)\}$$

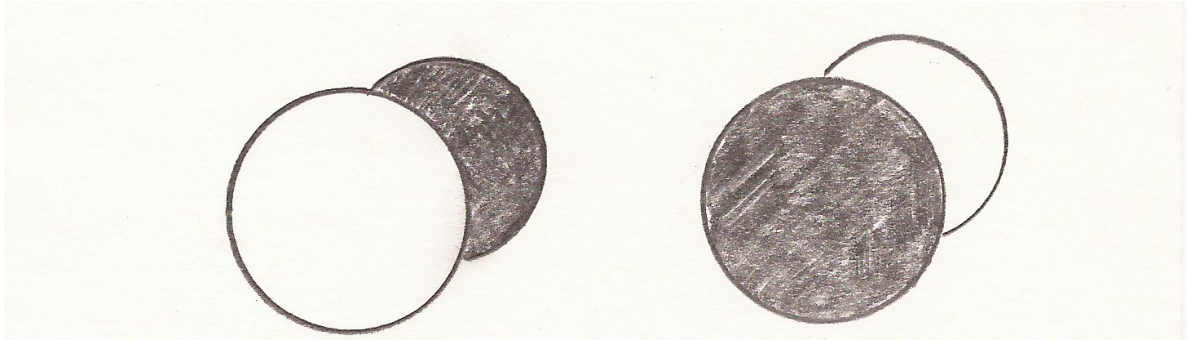
Ross's semantics for picture descriptions

In one picture, there is a man on a couch.

$$\exists x.\mathbf{picture}(x) \wedge [x]\exists y\exists z[\mathbf{man}(y) \wedge \mathbf{couch}(z) \wedge \mathbf{on}(y,z)]$$

Subset semantics: There is an x s.t. x is a picture in w_0 , and for all worlds w in $[\![x]\!]^{M,G,w0}$, there is a y and a z such that $\mathbf{man}(w,y)$ and $\mathbf{couch}(w,z)$ and $\mathbf{on}(w,y,z)$.

Ross's argument

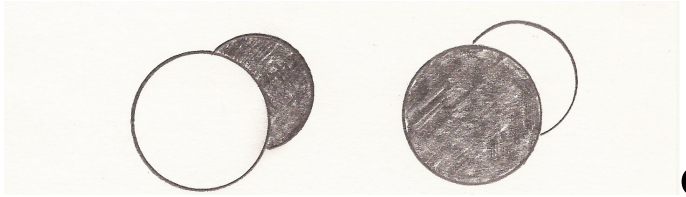


In the picture, there is a white ball in front of a black ball.

True with reference to the picture on the left.

False with reference to the picture on the right.

Ross's argument



o

Suppose the pictures have identical propositional semantic values, along the lines of "there is a white ball and a black ball". We can't get different truth values for these sentences, because the pictures enter into the subset semantics for the in the picture construction via their propositional semantic values.

In picture 1, there is a white ball in front of a black ball.

In picture 2, there is a white ball in front of a black ball.

Viewpoint-centered semantics

Pictures have viewpoint-centered semantic values.

Independently *in front of* has a hidden viewpoint parameter, together with its two overt arguments.

The *in the picture* construction binds a viewpoint parameter in its complement, and both worlds and viewpoints are quantified in the semantics. Semantics for [in x, ϕ]:

For all $\langle w, v \rangle$ in $[\![x]\!]^{M,G,w0,g}$, $[\![\phi]\!]^{w,g[v0 \mapsto v]} = 1$.

Analogy to de se semantics for PRO

The underlying attitudes are agent-centered (Lewis).
Dox$(w, x, w', x') = \langle w', x' \rangle$ is a doxastic alternative for x in w.

Infinitive-embedding verbs bind a variable contributed by PRO, in implementation from Chierchia 1989.

Shaky believes [PRO to have at four units of fuel] (in Italian).

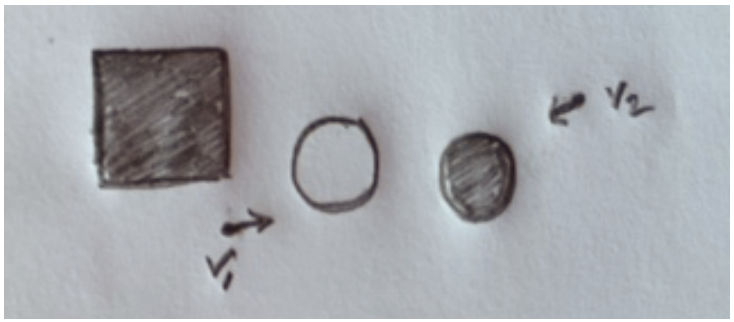
Shaky wants to [PRO to have at at least four units of fuel].

Viewpoint-centered semantics for *in front*

On the route to school, there is bike rack in front of a big oak. The bike is locked there.

Problem: too much information in pictures

p_1 p_2



w_2

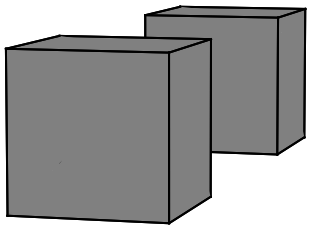
$p_1 = \Pi(w_2, v_1, M, G)$, therefore $w_2 \epsilon [\![p_1]\!]^{M,G}$ (propositional).

$p_2 \neq \Pi(w_2, v_2, M, G)$, because the cube is in view in the background.

$\neg\exists v[p_2 = \Pi(w_2, v, M, G)]$, therefore $w_2 \notin [\![p_2]\!]^{M,G}$ (propositional). Therefore $[\![p_1]\!]^{M,G} \neq [\![p_2]\!]^{M,G}$, propositionally.

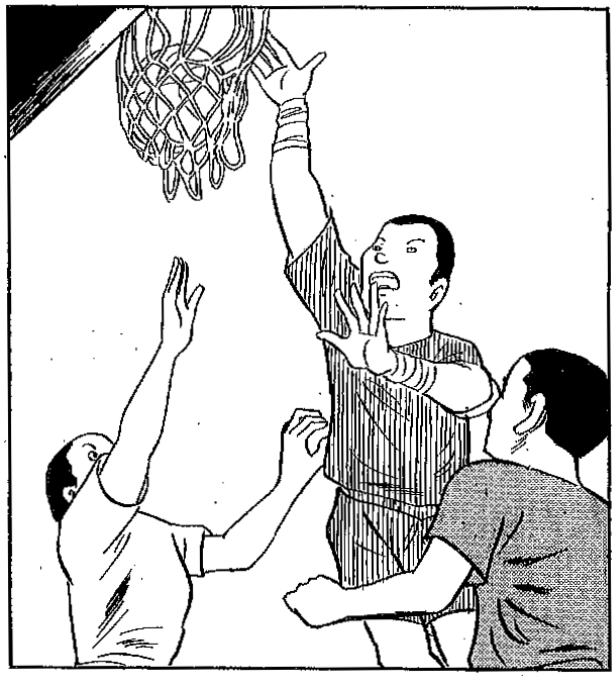
Pictorial content is strong

There are two cubes.



Pictorial content is weak

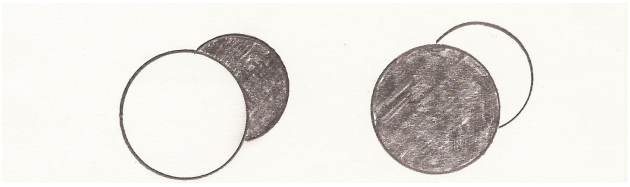
A boy of ordinary stature is sinking a basket.



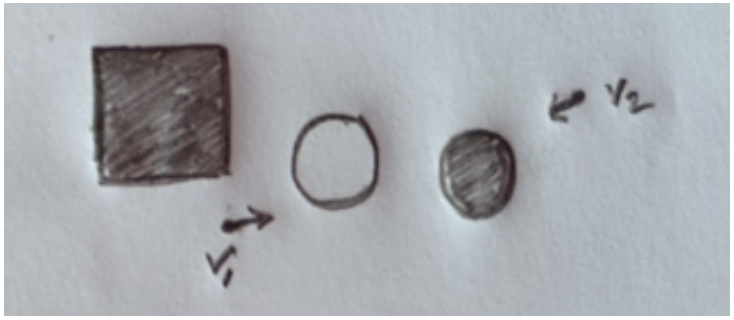
In a realistic model, it could be an acrylic statue of a boy.

The boy could be twice ordinary stature, and further away.

Ross's example does not work as assumed in geometric semantics



p_1 p_2



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$\neg \exists v[p_2 = \Pi(w_2, v, M, G)]$, therefore $w_2 \notin [\![p_2]\!]^{M,G}$ (propositional). Therefore $[\![p_1]\!]^{M,G} \neq [\![p_2]\!]^{M,G}$, propositionally.

Possibility of decoding viewpoint-centered proposition from proposition

$$\mathcal{D}(q) = \left\{ \langle w, v \rangle | [\![\Pi(w', v', M, G)]\!]^{M,G} = q \right\}$$

Semantics for [in x, ϕ]:
For all $\langle w, v \rangle$ in $D([\![x]\!]^{M,G,w0,g})$, $[\![\phi]\!]^{w,g[v0 \mapsto v]} = 1$.

Decoding requires access to M and G.

String worlds

World S1

`_r_y[bw)_y_y_r_`

ruby, opal, picture of a ruby in front of an opal, opal, opal, ruby

`r`	ruby
`y`	opal
square bracket	front of picture
round bracket	back of picture
`b`	ruby in picture
`y`	opal in picture

Indices for discourse referents

`2r_y1[bbw)_r_y_r_y_`

1 ultimate discourse referent, a picture
2 penultimate discourse referent, a ruby

Centering

```
r_y[bbw)_r_y>r_y_
r_y[bbw)_r_y<r_y_
```

- `>` center looking towards a ruby in front of an opal
- `<` center looking towards an opal in front of a ruby

```
There is a ruby adjacent to an opal.
regex [[Sit & OnePic] .o. New .o. Opal
                .o. New .o. Ruby .o. Adjacent].l;
6.8 Kb. 48 states, 128 arcs, Circular.
2y1r>[bw)_
>2y1r_(bwb]_y_
2y>1r_y_[bw)_y_
<1r2y_(bb]_y_r_r_y_y_
>2y1r_y_y_(www]_
<[bb)_y2y1r_
<(wbw]2y1r_y_
<1r2y_[wwbbww)_y_y_r_y_y_y_y_r_
<[wbwwbwb)_y2y1r_r_r_r_r_y_
<2y1r_(wb]_r_
```

```
There is a ruby adjacent to an picture.
regex [[Sit & OnePic] .o. New .o. Picture
                .o. New .o. Ruby .o. Adjacent].l;
5.1 Kb. 28 states, 84 arcs, Circular.
<1r2[bb)_r_r_y_y_
2(bwb]1r<r_r_r_
1r>2[wwbbwb)_r_
1r>2[ww)_r_
>1r2(wwbw]_
>1r2[bbbb)_
1r<2(bwwwb]_
>2[bb)1r_r_
_r<1r2(bw]_y_r_r_y_y_r_y_r_y_r_y_r_y_
<1r2[wb)_y_r_
<r2(wb]1r_y_
```

```
There is a ruby immediately in front of an opal.
regex [[Sit & OnePic] .o. New .o. Opal
          .o. New .o. Ruby .o. Infront].l;
5.6 Kb. 36 states, 92 arcs, Circular.
>[wb)1r2y_r_r_r_r_y_r_r_y_r_
_(bww]>r_y_r_r1r2y_
2y1r_[bb)<y_r_r_y_
>[bw)1r2y_
_r>(bwwwbbww]_y_y_r_y1r2y_y_
2y1r<y_r_[wb)_y_r_y_y_y_r_r_y_y_
>(wbwbbwb]_y_y1r2y_r_
2y1r<[bwbww)_r_r_
>[wb)1r2y_r_
>[wbwbb)_r1r2y_r_r_y_
_(bb]>r1r2y_y_r_r_
```

Situation S5a with a picture of a ruby in front of an opal at dref1.

```
_r_y1[bw)_r_y_r_y_
--------------------------
_(wbbb]>ry_[ww)_(bw]_
_(wbb]>ry_r_
_[wwwwwbb)>ry_[wbb)_(wwbb]_
_[ww)_y>ry_r_[www)_[wb)_y_
_(bwbb]>ry_y_(ww]_
_(ww]_[wwbw)>ry_[wb)_[bb)_
_r_[bww)_[wbbww)_[bbb)>ry_[wbw)_r_y_
_[bww)_[bb)>ry_[bbwb)_
_(bb]_(wb]>ry_(bb]_[bwbw)_r_
```

```
Situation S5b with a picture of an opal in front
of an ruby at dref1.
_r_y1[wb)_r_y_r_y_
------------------------
_[wwbw)_r_[ww)_(wb]>yr_y_r_
_[bww)_(bbbw]>yr_y_
_[ww)>yr_[ww)_(bw]_
_(wb]_y_(bbbwwwb]_[bb)>yr_(wbb]_[bb)_[bbww)_r_y_(wb
_r_(wbwbw]>yr_y_r_
_y>yr_(ww]_[bwb)_[bww)_(wwbb]_(bw]_y_(bwb]_(bwb]_(w
_y_ry<[bw)_[bbw)_
_(bbwb]_(wbw]>yr_(bb]_(bwb]_[wwbb)_(bw]_[www)_
_[bbbw)>yr_(bw]_r_[bw)_
```

The centered contents are different.

Compare propositional contents

```
define PCa [CCa .o. CtoZero].l;
define PCb [CCb .o. CtoZero].l;
PCa - PCb
2.2 Kb. 1 state, 0 arcs, 0 paths.
PCb - PCa
```

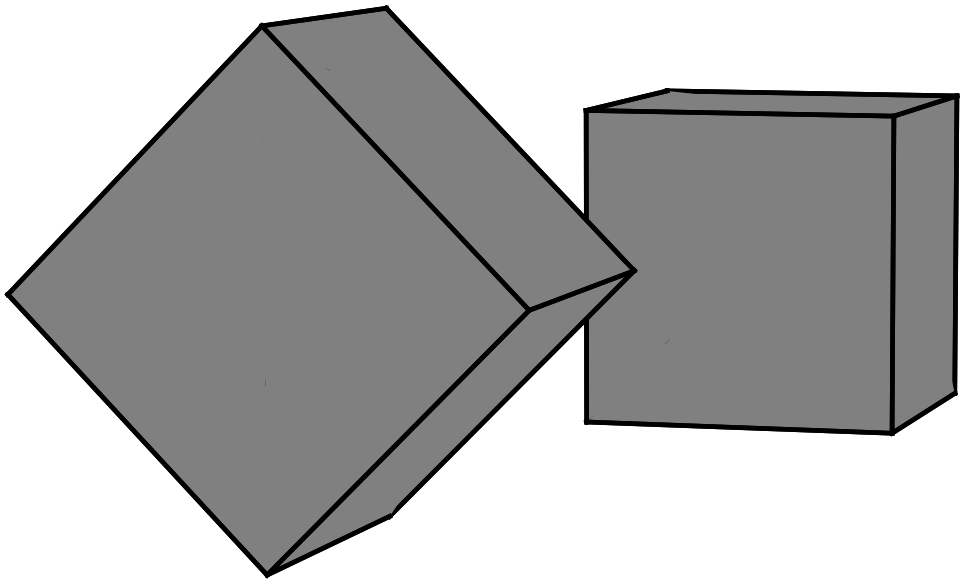
The set differences between the propositional contents PCa and PCb are the empty set, indicating that the propositional contents are the same. This reconstructs Ross's argument in finite state intensional semantics for pictures.

Why did it work?

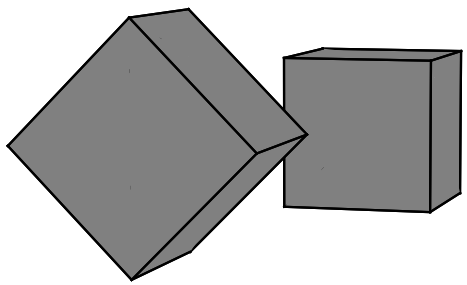
Pictures and the semantics of pictures were constructed to carry no “extra” information. These should have the same content (not verified).

`[bw)`

There is a ruby immediately in front of an opal.

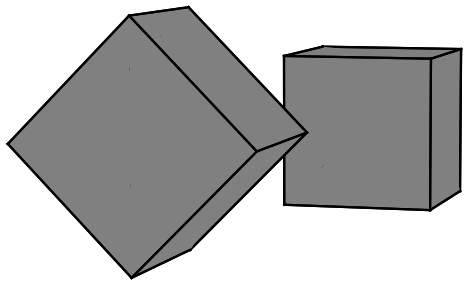


I own two cubes. This is how they are oriented.



The picture is intended as conveying information about the relative orientation of my two cubes, and nothing else.

I own two cubes. This is how they are oriented.



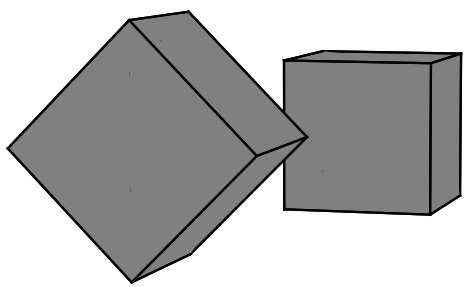
The picture is intended as conveying information about the relative orientation of my two cubes, and nothing else.

Marking rule

Mark a point in the picture plane black if the projection line from the viewpoint through that point intersects the edge of an object that is an element of $g(2)$ before it intersects any other part of an object that is an element of $g(2)$, otherwise in gray if it intersects some object that is an element of $g(2)$, and otherwise in white.

I own two regular polytopes$_2$.

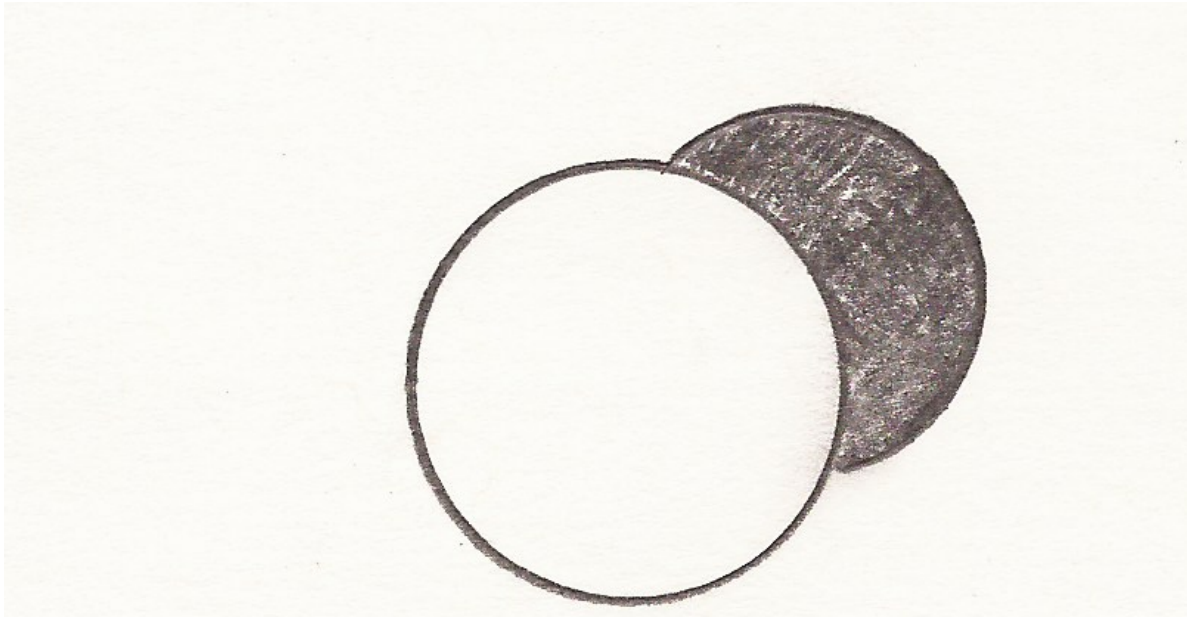
(accommodate marking rule)



The one in front is made of magnesium.

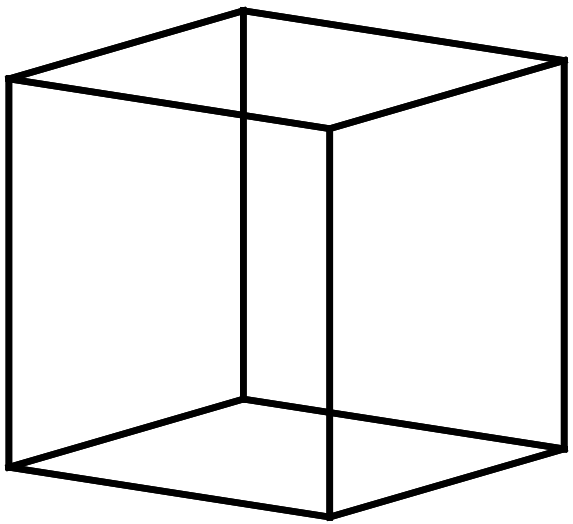
I own two spheres$_2$.

(accommodate marking rule)



The one in front is black.

Argument from ambiguity



Argument from continuity editing