12. Kant and Handedness

1. Incongruent Counterparts

- "Concerning the Ultimate Foundation of the Differentiation of Regions of Space" (1768).

**Claim**: Absolute space is necessary to explain the existence of incongruent counterparts.

- An incongruent counterpart is a *certain type* of mirror image.

[An incongruent counterpart is]...an object which is completely like and similar to another, although it cannot be included exactly within the same limits."
• Maps (1) and (2) reproduce the same relations between objects.
• A relationist must say they are the same.
• An absolutist can say they are different; namely, they differ in their locations with respect to absolute space.
Two types of mirror image

Let $O$ be an object and let $O'$ be its mirror image.

(1) $O'$ is a congruent counterpart of $O$ if it can be made to coincide with $O$ by rigid motions.
Two types of mirror image

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\[ \begin{array}{c}
E \\
E
\end{array} \]
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   \[E \quad \bar{E}\]

2. $O'$ is an **incongruent counterpart** of $O$ if it *cannot* be made to coincide with $O$ by rigid motions.

   \[F \quad \bar{F}\]
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\[
\begin{array}{c}
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\text{F}
\end{array}
\]

*Important Fact*: Whether or not a mirror image is an incongruent counterpart depends on the properties of the space it is located in.
• If the space is 3-dimensional, then F and its mirror image are congruent counterparts.
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• If the space is 2-dimensional and non-orientable, then F and its mirror image are congruent counterparts.

*Example:* A Möbius strip.
• If the space is 2-dimensional and non-orientable, then \( F \) and its mirror image are congruent counterparts.

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• Obtained by identifying edge points \( x \) with \( x' \), and \( y \) with \( y' \) on a 2-dim strip.

*Result:* A global "twist" that allows the mirror image of \( F \) to be rigidly transported around the entire space back onto \( F \).
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**Modified definition:**

An object is an *incongruent counterpart* of another if they cannot be made to occupy the same place by rigid motions in a local (closely surrounding) region of space.

- An object is said to possess *handedness* (chirality) just when it and its mirror image are incongruent counterparts.

- An object is said to lack *handedness* (chirality) just when it and its mirror image are congruent counterparts.
2. Kant's Argument for Absolute Space

"Let it be imagined that the first created thing were a human hand, then it must necessarily be either a right hand or a left hand."

• **But:** A relationist cannot determine the handedness of an object in the absence of other objects.

• **So:** Relationalism is not adequate.

• Left and right hands agree on all relational properties.

• **Absolutist:** They disagree on their locations with respect to absolute space.
Letter Example Again

F  F

• Do F and its mirror image have the same relational properties?
• Depends on how many properties one is willing to consider as relational.

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG.

THE QUICK BROWN ☞FOX JUMPED OVER THE LAZY DOG.

• F and its mirror image differ in their relational properties to the other letters in the sentence.
  - There is no way to make the mirror image of F fit into the sentence in the same way that F does.
  - Similarly, there is no way to fit a right hand into a left-handed (Freddy Krueger) glove (and *vice versa*).
• **But:** How can a relationist determine the handedness of an object when there are no other reference objects to define distinguishing relational properties?

• **Moreover:** What if such reference objects themselves have been reflected?

**THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG.**

• Since F and its mirror image share all relational properties in these sentences, a relationist will not be able to distinguish them.

• **Absolutist intuition:** Aren't F and its mirror image distinct, independent of their relations to other objects?
Relationist's Reflection Argument

- **Suppose**: Absolute space exists.
- **Then**: The following two universes must be possible:

  ![Diagram](attachment:diagram.png)

  - An absolutist must claim the reflection produces distinct worlds.
    - *They differ on their values of absolute position.*
  
  - A relationist will claim that the reflection does not produce distinct worlds.
    - *Since the relations between material objects are unaffected (and there's no such thing as absolute space), the worlds are not distinct.*
Possible Absolutist Retort:

- Would a reflected world be indiscernible from an unreflected world?
- Replace Spock with a decaying Cobalt-60 atom:

\[
\begin{align*}
\text{Co}^{60} & \rightarrow \text{Ni}^{60} + e^- + \bar{\nu}_e \\
\text{Co}^{60} \text{ decay} & \quad \text{Mirror Co}^{60} \text{ decay}
\end{align*}
\]

- Co\textsuperscript{60} decay (electron emitted in direction of nuclear spin) is observed more often than Mirror Co\textsuperscript{60} decay (electron emitted in opposite direction of nuclear spin) (Wu et al. 1957).
- Evidence that the weak force (that governs decay) violates mirror symmetry (i.e., "parity").
• *Absolutist Claim*: The reflected and unreflected worlds are *not* observationally indiscernible.
  - *In world 1, the Co\textsuperscript{60} atom decay occurs more frequently than in world 2.*

• Onus is now on the relationist to explain the physical difference between worlds 1 and 2.
  - *Recall Clarke's Dynamic Shift, with parity-violating experiments now replacing inertial effects.*
Let it be imagined that the first created thing were a Co$^{60}$ decay process, then it must necessarily be either a right-handed Co$^{60}$ decay process, or a left-handed Co$^{60}$ decay process... and there's a law-like physical difference between the two!

- Can a relationist both *ground* the distinction between right- and left-handed processes and *explain* why one is more probable than the other?

(a) Claim that the difference is *intrinsic*: Co$^{60}$ decay processes possess an intrinsic monadic (non-relational) property that *both* determines their handedness *and* their weak-force-governed behavior.

(b) Claim the difference is *extrinsic*:

- What determines whether the first created Co$^{60}$ decay process is right- or left-handed is its relation to all subsequent Co$^{60}$ decay processes.

- *And*: It is a brute lawlike fact (in need of no further explanation) that one of these decay processes is more probable than the other.
A Lingering Concern about Option (b)

- What explains Newton's First Law? How does a force-free object know to move inertially?
  - Absolutist: A *local* interaction between spacetime and the object (local spacetime "feelers"?).
  - Relationist: A *nonlocal* correlation between the object and other objects (nonlocal *inertial* antennae?).

- Similarly: What explains the parity-violating weak force? Why do Co\textsuperscript{60} atoms prefer decay modes of one chirality rather than another (given chirality is not intrinsic)?
  - Absolutist: A *local* interaction between spacetime and the object.
  - Relationist: A *nonlocal* correlation between the object and other objects (nonlocal *weak-force* antennae).

- Is one set of mysterious antennae (absolutist) better than two (relationist)?