Machian Comparativism about Mass

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Slides available at
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A1. Virtual particles
A2. Naturalness
A3. LHC, dark matter & gravity

B1. Computer simulations
B2. Model building
B3. Novelty & Credibility

www.lhc-epistemologie.uni-wuppertal.de/
The property of having mass is a determinable that appears to have two kinds of determinates. On the one hand, we naturally think that something with mass has a determinate intrinsic property, a property it has independently of its relationships with other material bodies. But we also think that things with mass stand in various determinate mass relationships with one another, such as $x$ being more massive than $y$ or $x$ being twice as massive as $y$.

(Dasgupta, 2013, p.105)
Assumptions

- Newtonian Gravity
- Equivalence between gravitational and inertial mass
- Scale-invariant mass relations: ‘Mass ratios’ (Baker, ms)
### Definitions

#### Absolute mass magnitudes
- Set of monadic properties
- Cardinality: $2^{\aleph_0}$
- Totally ordered & Concatenation structure (‘addition’)
- Transworld identity (quiddities)
→ totally ordered semi-group

#### Mass relations
- Set of binary relations
- Cardinality: $2^{\aleph_0}$
- Totally ordered & Concatenation structure (‘multiplication’)
→ totally ordered group
Absolute masses → mass ratios
- Always possible
- Unique
Absolute masses → mass ratios
  - Always possible
  - Unique
Mass ‘ratios’ → absolute masses
  - Constraint required (Roberts, ms; SMS2016 Geneva)
How do the determinates relate? Part I
Mathematics

Absolute masses $\rightarrow$ mass ratios
- Always possible
- Unique

Mass ‘ratios’ $\rightarrow$ absolute masses
- Constraint required (Roberts, ms; SMS2016 Geneva)
- Non-unique: many-to-one
(Metaphysical) Absolutism
The determinate mass relations obtain in virtue of determinate absolute masses.

(Metaphysical) Comparativism
The determinate mass relations do not obtain in virtue of determinate absolute masses.
Outline

1. The argument for Comparativism
2. The threat to comparativism
3. Machian comparativism
4. Metaphysical parsimony & Explanatory adequacy
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The Main Question

Metaphysical comparativism requires us to prove:

Dynamic Comparativism

Physics (i.e. Newtonian Gravity) depends only on the mass ratios, not on further absolute masses grounding those ratios. In slightly stronger words: metaphysical comparativism is empirically equivalent to metaphysical absolutism.

The Big Question: Is a Leibniz Mass Scaling merely an identity operation, or does it lead to empirical differences?

(Active) Leibniz Mass Scaling

A uniform scalar multiplication of each of the absolute mass magnitudes, *ceteris paribus*. 
General Schema for the Comparativist Argument

**P\textsubscript{dyn}**  **Dynamic Comp:** (Metaphysical) comp is empirically equivalent to (metaphysical) abs.

**P\textsubscript{occ}**  **Occamist norm:** All other things being equal (i.e. P\textsubscript{dyn}), we should favour theories that are metaphysically more parsimonious.

**P\textsubscript{par}** (Metaphysical) comp about mass is metaphysically more parsimonious than (metaphysical) abs.

**C** (Metaphysical) comp about mass should be favoured over (metaphysical) abs.
### General Schema for the Comparativist Argument

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{dyn}}$</td>
<td><strong>Dynamic Comp:</strong> (Metaphysical) comp is empirically equivalent to (metaphysical) abs.</td>
</tr>
<tr>
<td>$P_{\text{exp}}$</td>
<td><strong>Explanatory Adequacy:</strong> (Metaphysical) comp is at least as explanatorily adequate as (metaphysical) abs.</td>
</tr>
<tr>
<td>$P_{\text{occ}}$</td>
<td><strong>Occamist norm:</strong> All other things being equal (i.e. $P_{\text{dyn}} \land P_{\text{exp}}$), we should favour theories that are metaphysically more parsimonious.</td>
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<tr>
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The argument for Comparativism
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Metaphysical parsimony & Explanatory adequacy

Comparativism’s bucket

\[ F_g = G \frac{mm}{r^2} \]

\[ v_e = \sqrt{\frac{2GM}{r}} \]

Double Mass

(Baker, ms; NCMM DPhil)
1. The argument for Comparativism
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Where to go from here?

**Absolutism**
The comp bucket shows that absolute masses are real, i.e. empirically meaningful → metaphysical absolutism

**Regularity comp**
Accept that the comp bucket proves realism about absolute masses, but insist that those can be grounded in mass ratios (and other non-mass facts). *(NCMM 2017; SMS2016 Geneva)*

**Machian comp**
Modify the syntax (i.e. equations) such that the comp bucket is avoided (whilst retaining empirical equivalence to abs) → anti-realism about absolute masses
Strategy: Varying Newton’s ‘Constant’

- Modify the absolutist law by substituting Newton’s Constant for a variable—across possible worlds only, not across space and time.

\[ G = G(W) = \gamma / m_W \]

\[ v < \sqrt{\frac{\gamma m_i}{r m_W}} \]
The Alpha Mass

- **Analogy:** Neumann’s Body Alpha *(Neumann, 1870)*

- **Problems:**
  1. What about worlds that do not contain $m_\alpha$?
  2. Violates generalism *(Saunders, 2003; Dasgupta, 2009; Pooley, ms; Møller-Nielsen, 2016)*
  3. Is this really different from absolutism?
‘Machianism’: sum of all mass ratios

- $m_W = \sum_k m_k$;
- $F_{\text{grav},ij} = \gamma \frac{m_i m_j}{r^2 \sum_k m_k}$
- $v < \sqrt{\frac{\gamma}{r} \sum_k \frac{m_k}{m_j}}$
Potential Problems

1. Counter-intuitive/ holism
2. Empirically inequivalent?
3. Requires absolutism about $r$
4. Requires additional ‘additive structure’
5. Metaphysical parsimony & explanatory adequacy?
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Measuring Metaphysical Parsimony

- Naive intuition: absolutistism acknowledges both absolute masses and mass relations while comparativism only recognises the latter → comparativism has a ‘lower metaphysical bill’
- Both views fundamentally commit to different types of building blocks. How to compare metaphysical parsimony?
- Quantitative Parsimony?
  - Absolutism: $n$ absolute masses
  - Comparativism: $n^2$ or $n(n - 1)$ mass relations
**Quantitative Parsimony?**

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- Machian comp: additional concatenation structure (‘addition’)
Recall: constraint required on mass relations if they are to be interpretable as mass ratios at all

*Either:* meta-relations required to ensure that the constraint holds → loss of quantitative and qualitative parsimony

*Or:* if the mass relations conspire to behave as if they obtained in virtue of absolute masses, one should infer to the best (i.e. only) explanation: absolutism
Metaphysical comparativism needs to prove that it is empirically adequate. It needs to respond to the comparativist bucket argument.

‘Machian’ comparativism is the most viable form of comparativism—it successfully responds to the bucket argument without admitting the empirical meaningfulness of absolute masses. However, like all forms of comparativism it fails to explain the transitivity of mass ratios. Moreover, its metaphysical parsimony is even more questionable than other forms of comparativism.

Perhaps the lesson to learn from this is that we should favour ‘Machian absolutism’
D.J. Baker (manuscript), ‘Some Consequences of Physics for the Comparative Metaphysics of Quantity’


O. Pooley (manuscript), ‘The Reality of Spacetime’


Extra Slides
Kinematic Comparativism (⇐⇒ dimensionfulness)

For any dimensionful determinable, such as mass, the magnitude predicated of any particle can only be meaningfully reported or expressed in terms of how this magnitude relates to the magnitude of another particle having the same determinable property.

- Therefore, absolute mass magnitudes need to be represented by a numerical quantity times a unit.
- This representation is non-unique (conventional choice of unit).
Kinematic comparativism $\rightarrow$ (metaphysical) comparativism

Metaphysical comparativism requires us to prove:

**Dynamic Comparativism**

Physics depends only on the mass ratios, not on further absolute masses grounding those ratios. In other words, metaphysical comparativism is empirically adequate.
Three Approaches to Empirical Adequacy

1. **Symmetry Approach:** Are Leibniz Scalings symmetries of Newtonian Gravity, or not?

2. **Undetectability approach:** Are absolute masses undetectable? (Dasgupta, 2013)

3. **Possibility counting:** Does comparativism correctly generate the set of empirically distinct possible worlds allowed by Newtonian Gravity?
Empirical Equivalence:
The comparativist laws of nature *uniquely* (i.e. deterministically) evolve each set of initial conditions allowed by the theory into a dynamically possible model, such that the *whole* set of empirically distinct dynamically possible models generated by the absolutist theory is reproduced (i.e. *completeness*) and no models that are empirically distinct from each of the absolutist solutions are generated (i.e. *soundness*).
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“Leibniz Mass Scaling is ill-defined until we are told what happens to the strength of the law (as represented by Newton’s constant)”

Motivations:

1. When changing mass units, we also change the units of $G$.  
   (Roberts, ms)
2. Empirical access only to $G \cdot m$.

There is no problem: *ceteris paribus* clearly means keeping the laws the same.
Different chains lead to a plurality of distinct but indistinguishable worlds corresponding to each single Web-world → loss in inter-world metaphysical parsimony