Lecture 16
Black, Meyer, and the Law of Likelihood

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Introduction

- Meyer's theory was widely preferred to Black's, especially in continental Europe, for about a decade after it was published.
- The great French chemist Lavoisier accepted Black's theory but still said: *There are few modern books of chemistry which display more genius than this of M. Meyer.* (1776)
- Black's student and colleague John Robison said of Meyer's book: *There is scarcely to be seen a book in which there is such a number of injudicious experiments, and unskilful attempts to reason from them.* (1803)
- It is now standard to praise Black's work as a model of cogent reasoning from experiment, although Meldrum (1930) said the decision between these theories was just a matter of taste.
- None of these evaluations of Black's and Meyer's arguments is supported by cogent reasons; mostly they aren't supported by any reasons at all. Today we'll see how to do better.

Identification of the theories

	B	*M*
1	Calcareous earth = lime + fixed air + water.	Calcareous earth = lime - causticum + water.
2	Strongly heating calcareous earth drives off the fixed air and water and adds nothing.	Strongly heating calcareous earth drives off the water and adds causticum.
3	In Marggraf's distillation of calcareous earth, no water was converted into air.	In Marggraf's distillation of calcareous earth, some water was converted into air.
4	When calcareous earth is placed in acid, the air released comes from the calcareous earth.	When calcareous earth is placed in acid, the air released comes from the acid.
5	Lime has greater attraction for fixed air than for water.	Causticum is acidic.

Table 1

Evidence concerning weight loss

E_1

When Marggraf distilled calcareous earth he obtained water that equaled 3% of the weight of the calcareous earth used. When Black dissolved calcareous earth in acid there was a loss of weight equal to 40% of the weight of the calcareous earth. When Black calcined calcareous earth it lost 43% of its weight.

Expectation given B

- The 3% is the water in calcareous earth, by B_3.
- The 40% is the air in calcareous earth, by B_4.
- The 43% is the water + air in calcareous earth, by B_1 & B_2.
- The third number should be the sum of the other two.

Expectation given M

- The 3% is the amount of water in calcareous earth not converted to air in Marggraf's experiment, by M_3
- The 40% is air released by the acid when calcareous earth dissolved, by M_4.
- The 43% is the water in calcareous earth less the causticum added by calcination, by M_1 and M_2.
- There is no reason to expect the third number to be the sum of the other two.

Application of the law of likelihood

- Given B, it is expected that the third number is the sum of the other two.
- Given M, there is no reason to expect this.
- So $p(E_1|B) > p(E_1|M)$.
- So, by the law of likelihood, E_1 favors B over M.

Evidence concerning the crust on lime water

E_2

(a) A crust of calcareous earth forms on the surface of lime water exposed to the atmosphere. (b) When calcareous earth is combined with any ordinary acid and then exposed to the atmosphere, the acid doesn't leave the earth and go into the air.

Expectation given B

(a) There should be some fixed air in the atmosphere. (The fixed air in calcareous earth must have come from somewhere and it goes back into the atmosphere when calcareous earth is calcined.) The lime in lime water combines with this fixed air at the surface, by B_5. That gives calcareous earth, by B_1. So (a) is expected.

(b) B says nothing relevant to this.

Expectation given M

(b) M says nothing relevant to this.

(a) Given (b) and M_5, (a) is the opposite of what would be expected.
Meyer said: *what a singular acid [causticum] must be, since it does not remain with the lime like other acids, but abandons it and prefers to unite to the air.*

Application of the law of likelihood

- Neither B nor M says anything about (b).
- Given (b), B predicts (a) and M predicts the opposite.
- So $p(E_2|B) > p(E_2|M)$.
- So, by the law of likelihood, E_2 favors B over M.

Evidence concerning the color of violet syrup

E_3

Calcareous earth combined with any ordinary acid either leaves syrup of violets blue or turns it red (depending on whether or not there is excess acid). Lime turns syrup of violets green.

Expectation given B

- B doesn't predict E_3.
- E_3 can be explained, consistently with B, as follows:
  - Lime is an alkali. Hence calcareous earth + acid is a compound of alkali and acid.
  - This will be neutral if there isn't too much acid, hence leave syrup of violets blue.
  - If there is more acid than can combine with the lime, it will turn syrup of violets red.
- So E_3 isn't improbable given B.

Expectation given M

- According to M, lime is calcareous earth combined with causticum, which is an acid. So, given M and the first part of E_3, lime should either leave syrup of violets blue or turn it red. The one thing it shouldn't do is turn syrup of violets green.
- So E_3 is improbable given M.

Application of the law of likelihood

- E_3 is improbable given M but not given B.
- So $p(E_3|B) > p(E_3|M)$.
- So, by the law of likelihood, E_3 favors B over M.

Question

1. Let B and M be as in Table 1. For each of the following three pieces of evidence, say whether it favors B or M over the other and justify your answer using the law of likelihood.
   - E_1 When Marggraf distilled calcareous earth he obtained water that equaled 3% of the weight of the calcareous earth used. When Black dissolved calcareous earth in acid there was a loss of weight equal to 40% of the weight of the calcareous earth. When Black calcined calcareous earth it lost 43% of its weight.
   - E_2 (a) A crust of calcareous earth forms on the surface of lime water exposed to the atmosphere. (b) When calcareous earth is combined with any ordinary acid and then exposed to the atmosphere, the acid doesn't leave the earth and go into the air.
   - E_3 Calcareous earth combined with any ordinary acid either leaves syrup of violets blue or turns it red (depending on whether or not there is excess acid). Lime turns syrup of violets green.

Reference

Patrick Maher.
The confirmation of Black's theory of lime.
Studies in History and Philosophy of Science, 30:335–353, 1999.
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