Four Kinds of Boundary*
–From an Ontological Point of View–

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ABSTRACT. Casati and Varzi have developed a theory of boundary based on extensional mereotopology and the distinction between *fiat* and *bona fide* boundaries. Firstly, I point out some problems in their theory that are related to the contact of bodies. Next, I propose a way of classification of boundaries into four kinds based on substance ontology and an alternative distinction between *potential* and *actual* boundaries. Finally, I will show that my way of classification makes it possible to solve the problems above.

1 Casati and Varzi's Theory of Boundary

In [Casati and Varzi 1999], Casati and Varzi insisted that the contact is only possible between a closed entitiy and an open entity, while neither the contact of two closed entities nor that of two open entities is possible, as a result of adopting the system of General Extensional Mereotopology with Closure Conditions (GEMTC).

However, such a position brings about the following puzzles:[1]

(1) Puzzle of Inner Boundary Which of *e.g.* the right-half of a body and its left-half does the boundary between them belong to? Which is an (partly) open body and which is a closed one?

(2) Puzzle of Fission When a body is separated into two, how does one boundary at the cross section become two?

(3) Puzzle of Collision If closed bodies cannot make contact with each other, how is collision possible?

To solve the puzzle(1), Casati and Varzi introduce the distinction between *fiat* and *bona fide* boundaries. According to them, in contrast with *bona fide* boundaries such as an outer boundary of a material body, we can take *fiat* boundaries such as the

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[1] In the following, I confine my argument to the problems related to two-dimensional boundaries of material bodies.

inner boundary shown above as Brentanian boundaries, in the sense that they are two coincidental boundaries.

As for the puzzle(2), they insist that we should not take fission as a phenomenon in which new surfaces that were trapped inside a body are brought to light. Rather, the outer surface of the body is progressively deformed until the body are separated into two halves.

They give two possible answers to the puzzle(3):

(a) The relation of touching between closed entities is not mereotopological but metric. Two closed entities are in touch if the distance between them is sufficiently small, or perhaps arbitrarily small.

(b) The two closed bodies *will* indeed come into contact. From the fact that two closed entities cannot *be* in contact it does not follow that they cannot *come into* contact, just as from the fact that two parts are connected it does not follow that they cannot be separated.

2 Difficulties in Casati and Varzi's Theory

In my view, all the solutions given above by Casati and Varzi have some difficulties.

Their solution to the puzzle(1) is only applicable to *fiat* inner boundaries such as that between the right-half and the left-half. So the puzzle remains for *bona fide* inner boundaries such as that between a red circle spot and its white surrounding in *e.g.* a Japanese national flag.

Admitting that this is truly problematic, they insist that the actual ownership of a boundary is not an issue that a mereotopological theory must be able to settle in such cases. According to them, it should be settled by a special theory such as that of a colored spot and its background. Perhaps the theory will determine that the boundary between a spot and its background belong to the former.

However, I don't believe that in all such cases we can fix which a boundary belongs to by some special theory. For example, how can we determine the belonging of the boundary between colored spots of primary colors, such as a green spot and a red spot? The problem is not the underdetermination of belonging by a mereotopological theory of boundary but its unnecessary constraining of asymmetry even to the cases where symmetry is due.

As for their solution to the puzzle(2) by reinterpreting fission as the deformation of outer boundary, there are cases which cannot be interpreted in their way: for example, the cases where fission begins from the center of the cross section. Besides, we will not be able to determine how the outer boundary is deformed, if a body is separated instantly.

Their possible answer(a) to the puzzle(3) seems a kind of fallacy of confusing different levels of granularity. They just avoided describing collision in the mesoscopic level of world by escaping into the microscopic level. Though they may maintain that their view of collision is supported by quantum mechanics, it does not follow from just physical facts in the actual world that real touching *cannot* occur among mesoscopic objects.

As they explain, collision is the dual phenomenon of fission. So in their possible answer(b), they cannot adopt the view that one of the two touching boundaries disappears while the other remains, since they rejected the corresponding view about fission. Consequently, they will have to admit that both of the two boundaries disappear at the moment of collision. This means that two bodies momentarily turns into one while they are touching, which is strongly against our intuition about collision; we never identify the two bodies just touching as one self-connected body.

3 Ontological Classification of Boundaries

I follow Casati and Varzi in characterizing a two-dimensional boundary of a material body as a concrete but immaterial entity that is specifically dependent upon it and yet that constitutes it in a broad sense. This makes the coincidence of two boundaries possible; because they are immaterial, they can be co-located, while because of their specific dependence on each material host, they can be individuated as two entities even though they are co-located.

However, I don't think that their restriction of coincidental boundaries to *fiat* boundaries is justified. I believe that whether a boundary is Brentanian or Bolzanian, namely, coincidental and so symmetrical or asymmetrical, is independent from whether it is *fiat* or *bona fide*.

In my view, what determines whether a boundary is Brentanian or Bolzanian is the number of substantial entities, whether *fiat* or *bona fide*, that is related to contact; Brentaninan coincidence is brought about by the contact of two substantial entities, while Bolzanian contact holds between one substantial entity and its complementary region or some entity defined using that region.[2] As it were, the asymmetry of Bolzanian boundaries results from a kind of ontological asymmetry concerning objects that make contact.

On the other hand, I propose to introduce a modal distinction between *potential* and *actual* as an alternative to the distinction between *fiat* and *bona fide*. This distinction is based on whether the substantial entities that make contact are actual or potential. According to this distinction, the boundary between *e.g.* two cities is actual and yet *fiat*, since cities are institutional entities. To the contrary, the boundaries between a heart and blood vessels may be potential and yet *bona fide*, since a heart and blood vessels are biological entities.

If we adopt the two ways of distinction above, we can classify boundaries into four kinds as follows:

[Table 1 on the next page]

As seen from the examples shown in the table, this classification is, strictly speaking, that of the situations in which boundaries appear rather than that of boundaries themselves. According to the view above, each boundary itself is Bolzanian and so it only belongs to a closed entity so as to bound its complementary region *from the outside* of that region. The difference between so-called Bolzanian and Brenanian boundaries

[2] I use 'the complementary region of an entity' as an abbreviation of 'the complementary region of the region which an entity occupies'.

Table 1. Four Kinds of Boundary

	Brentanian (symmetrical)	Bolzanian (asymmetrical)
actual	*e.g.* the coincidental boundaries between two bodies	*e.g.* the boundary between a body and its complementary region
potential	*e.g.* the coincidental boundaries between two halves of a body	*e.g.* the boundary between a (proper) part of a body and its complementary part of the body

is reduced to whether there is only one Bolzanian boundary or there are two coincidental Bolzanian boundaries. In that sense, this view does not oppose Brentanian and Bolzanian boundaries but rather reduce the former to the latter.

On the other hand, this view supports Brentano in rejecting Bolzano's 'open entity' that is on a par with a closed entity. An open entity is, if it is an entity at all, dependent on a closed entity in the sense that it is defined using the concept of complementary region of that closed entity. So if we define a hole as an entity that occupies some part of the externally connected region of its host, it turns out to be an open and dependent object. Similarly I take the complementary part of some proper part of a body as a part of the body that occupies the complementary region of that proper part and so an (partly) open and dependent object. Consequently, just as a hole cannot exist separated from its host, the complementary part of some closed part of a body cannot be moved away from that closed part.

4 Solutions to the Boundary Puzzles

If we accept the classification of boundaries above, the solutions to the boundary puzzles shown in the first section are straightforward.

Because there are two potential boundaries between the two halves of a body, there are no problems about the belonging of one boundary concerning either inner boundaries or fission. If one of the two parts is closed and the other is open, the latter cannot be separated from the former, since the latter is just the overlap of the complementary region of the former and the whole body. In such cases, there are only two independently movable objects: the closed part and the whole body.

The collision of two closed bodies is also possible, because two boundaries just coincide when they touch. Besides, since there are no separable open objects, we have no problems about the collision either of two open bodies or of an open body and a closed body.

References

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