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Hobbesian Reaction: Towards and Beyond Newton's Third Law of Motion

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RESUMEN

Intentaré mostrar aquí que la idea hobbesiana de reacción representa la culminación de la revisión y rechazo de la visión aristotélica de acción física —esto es, la visión de que la acción es resultado de (a) la aplicación continua de una fuerza (b) por parte de un cuerpo agente que está en contacto con el cuerpo movido—. Se puede decir que la primera parte de esta revisión la completó Filópono (en la Alejandría del siglo VI d.C.) al proporcionar una explicación causal del movimiento de los proyectiles y del de los cuerpos en caída libre basada en la presencia en el cuerpo movido de una fuerza impresa (luego llamada *impetus* por Buridan en el siglo XIV). Avempace, en el siglo XII, inició la segunda parte de esta revisión al atribuir una acción de resistencia al cuerpo movido (frente a la anterior de pasivo impedimento), una capacidad de ejercer una fuerza sobre el agente. Pero probablemente nadie antes de Hobbes aceptó todas las impicaciones de la consideración activa del paciente. Su idea de reacción significa que el cuerpo que es movido, no sólo puede convertirse en agente gracias a la impresión en él de un principio activo (como ya Filópono había defendido), o que incluso puede ejercer una fuerza sobre el agente (como Avempace dijo) sino que además ese paciente (1) deviene en agente siempre que otro cuerpo esté actuando sobre él, y (2) se hace agente, precisamente, con un movimiento contrario al del agente primero que actúa sobre él. Newton añadirá a esta idea un tercer matiz importante, a saber, (3) que esta reacción del paciente es igual a la acción ejercida sobre él. Creo, sin embargo, que esta idea puede encontrarse también en la filosofía de Hobbes, si no de forma explícita, sí implícitamente.

ABSTRACT

I will attempt to show that Hobbes' view of reaction represents the culmination of the revision and overthrow of the Aristotelian view of physical action — i.e. the view that action is the result of (a) the continual application of a force (b) by an agent body which is in contact with the moved object. It can be said that the first stage of that revision was undertaken by Philoponus (sixth century, A.D.) who provided a causal explanation of the motion of projectiles and falling bodies based on the presence in them of an impressed force (later on called impetus by Buridan in the fourteenth century). Avempace, in the twelfth century, started the second part of this revision by attributing an active role of resistance to the moved object, a capability to exert an action on the agent. But probably not before Hobbes did anyone fully recognize the implications of understanding resistance as active, not passive. His view of reaction meant that the patient, the moved object, not only may become agent by the impression in it of an active principle (as Philoponus already said), or that it may exert

a force upon the agent (as Avempace said), but that it (1) becomes agent insofar as it is being acted on, and (2) that it becomes an agent which acts, precisely, with a motion contrary to that of the first agent acting on it. Newton will add to Hobbes' view a third peculiarity, namely, (3) that this particular reaction of the patient is equal to the action exerted on it. This feature can, however, also be found, if not explicitly at least implicitly, in Hobbes' world view.

I. Reaction in the External Physical World.

Hobbes's world, as described in *De Corpore*, is "full, but withal fluid" [Hobbes (1655), IV.26, art.3, p. 417], that is, full of bodies in motion. Motion, rather than a result, is "either coeternal, or of the same duration with that which is moved" [Ibid.]. In other words, motion has existed since there were bodies. Let us observe these two components of the world separately, body and motion.

"Body is that, which having no dependance upon our thought, is coincident or coextended with some part of space" [Hobbes (1655), II.8, p. 102]. Thus body is, in a Cartesian fashion, essentially extension. Motion, on the other hand, is one of the two "most common accidents of all bodies"; the other is magnitude [Hobbes (1655), III.15, p .203]. And since an "accident" is "the manner by which any body is conceived" (or "that faculty of anybody by which it works in us a conception of itself") [Hobbes (1655), II.8, art.2, p. 103] to study or "conceive" bodies, then, means to study, primarily, their motions and their magnitudes. Magnitude, in its turn, is the only accident "which cannot be generated or destroyed" [Hobbes (1655), II.8, art.20, pp.116-7].[1] This leaves us with a characterization of motion as (a) the most common accident of bodies which (b) can be generated or destroyed.[2]

This said about the relationship between body and motion, we still need to know which kind of accident, in particular, motion is. "Motion is a continual privation of one place, and acquisition of another" [Hobbes (1655), II.8, p. 109].[3] This means that motion, any motion, is for Hobbes only locomotion. Mutation or alteration is not different: "mutation is motion of the parts either of the agent or of the patient" [Hobbes (1655), II.9, art.9, p. 126]. And this means that rather than saying that everything in Hobbes' materialistic world is matter and motion, we should say everything is matter and locomotion.

Action is motion also, but motion considered in reference to its effects, that is, it is motion of a body in so far as it causes effects on another body. And the meaning of "effects" here is quite specific in Hobbes: generation or destruction of some accident. "A body is said to work upon or act, that is to say, do something to another body, when it either generates or destroys some accident in it"[Hobbes (1655), II.9, art.1, p. 120]. Regarding the agent, two conditions are set for this "generation or destruction of accidents" to be pos-

sible. The agent must be (1) moved, and (2) contiguous (to the object it acts on). "There can be no cause of motion, except in a body contiguous and moved" [Hobbes (1655), II.9, art.7, p. 124]. And this must be so for two main reasons, each supporting one of the two conditions.

On one hand, the agent must be moved because otherwise it will not affect another body (i.e. it will not change its motion or rest). "As it is true that nothing is moved by itself; so it is true also that nothing is moved but by that which is already moved" [Hobbes (1655), IV.26, art.1, p. 412]. Motion can only proceed from motion. "Rest does nothing at all, nor is of any efficacy; and nothing but motion gives motion to such things as be at rest, and takes it from things moved" [Hobbes (1655), III.15, art.3, p. 213]. Hobbes supports this by explicitly defending — although with not minor modifications to which I will return later — the two first Cartesian laws of motion (which constitute the law of inertia in the latter): (1) "Whatsoever is at rest will always be at rest, unless there be some other body besides it, which by endeavoring to get into its place by motion suffers it no longer to remain at rest [...]. And that whatsoever is moved will always be moved, unless there be some other body besides it, which hinders its motion" [Hobbes (1655), II.8, art.19; also in III.15, art.1, p. 205; my italics];[4] and (2) "Whatsoever is moved, will always be moved in the same way, and with the same swiftness, if it be not hindered by some other moved and contiguous body" (my italics) [Hobbes (1655), III.15, art.1, p. 206].[5] These laws require indeed a moved agent to change the state of the patient, which is the first condition set by Hobbes in order to have action.

On the other hand — and this is the second condition to have an action — the agent must be contiguous (see italicized words in previous paragraph), a requirement not set by Descartes or Newton in their formulations of the law of inertia.[6] This contiguity is necessary because otherwise, according to Hobbes, we would not be able to explain why the patient moves in a determinate direction and with a determinate force [Hobbes (1655), II.8, art.19, pp.115-6].[7] Hobbes does not add here specifically the support for this idea he could draw from his own plenist view of the cosmos —which he defends at the end of his *De Corpore* and in which bodies are always in contact with bodies— but it could be added also.[8] There is nothing but contiguous bodies in this world.

Since this second condition set by Hobbes in order to have action helps clarify his position with respect to the law of inertia, central in a good part of the present discussion, a second important modification to that law should also be noted here before we go any further. Hobbes does not say that the moved, if not hindered, will continue in a straight line, as both Descartes and Newton affirm.[9] Hobbes says that the moved will continue "in the same way." His expression suggests that bodies may move, even without the influence of any other force, in a way which is not a straight line. This would

place Hobbes somewhere between Galileo's "circular inertia", and Descartes' two first laws of motion.[10]

As a conclusion from the observation of these two important modifications to the two first Cartesian laws of motion (inertia), we cannot say that Hobbes defended the latter. All we can say is that he adopted two very similar laws, but different in two crucial aspects — necessity of contiguity and lack of commitment to motion in a straight line.

Let us continue our exploration of action. If action requires that the agent be a moved object, it must require also some cause of that motion in the agent. That cause is what Hobbes calls the "power of the agent" which, he says, "is commonly called active power" [Hobbes (1655), II.10, art.1, p. 128]. Thus, "the power of the agent and the efficient cause are the same thing" [Hobbes (1655), II.10, art.1, p. 127]. The difference between them is that "cause is so called in respect of the effect already produced, and power in respect of the same effect to be produced hereafter; so that cause respects the past, power the future time" [Hobbes (1655), II.10, art.1, p. 128]. This difference is also referred to by Hobbes as motion as act (that is motion produced in the body) and motion as active power (motion that produces motion). "[I]f of three bodies the first put forward the second, and this the third, the motion of the second, in respect of the first which produceth it, is the act of the second body; but, in respect of the third, it is the active power of the same second body" [Hobbes (1655), II.10, art.6, p. 131]. The efficient cause (or the "power of the agent") is both the motion the agent has, and its power to move. And this means that "all active power consists in motion also" [Hobbes (1655), II.10, art.6, p. 131]. Wherever there is active power there is motion. And there is active power whenever motion is conveyed to a patient. "The agent has power, if it be applied to a patient; and the patient has power, if it be applied to an agent" [Hobbes (1655), II.10, art.1, p. 129].

Now that we know what action is and implies, we can talk about reaction. Its treatment falls under those actions considered with respect to the effects caused by the "active power" of the agent. Hobbes distinguishes in this respect three kinds of actions: (1) pressure, (2) resistance, and (3) restoration. The two last ones — this is worth noting for the purposes of this paper — are actions which have as agent a former patient which is now an agent acting in opposite direction to the first agent. Two main differences between them: in the first case, resistance, the action of the patient — which is now agent — (1) is simultaneous to the first action of the agent, and (2) applies to all bodies; in the second case, restoration, none of these are true: it takes place in a body precisely after it has been acted on, and it only occurs in certain bodies. But let us proceed slowly.

The first action, pressure, is defined by Hobbes as follows: "of two moved bodies one presses the other, when with its endeavour it makes either all or part of the other body to go out of its place" [Hobbes (1655), III.15,

art.2, p. 211]. Since "to go out of one's place" is the definition of motion, we could rewrite this definition of pressure by saying that to press is the endeavour which moves all or part of another body. This shows in which sense pressure is an instance of what action in general is (i.e. of that which "generates or destroys some accident"). Pressure is an action which generates or destroys one particular accident: motion.

In order to fully understand this definition of "pressure" we need to add a couple of important clarifications. First, the meaning of "endeavour". "I define endeavour to be motion made in less space and time than can be given; that is, less than can be determined or assigned by exposition or number; that is, motion made through the length of a point, and in an instant or point of time" [Hobbes (1655), III.15, art.2, p. 206]. Three clarifications are necessary. (1) We have seen above that motion can be act (motion "made" or produced) or motive power (motion that produces motion). Endeavour is of the first kind, as the definition says ("motion made in less space and time [...]"). (2) Endeavour is not indivisible motion — "for there is no such thing in nature" [Hobbes (1655) III.15, art.2, p. 206] — but undivided motion, that is, motion "whose quantity is not at all considered" [Hobbes (1655), III.15, art.2, p. 206]. And (3) "Whether there be resistance or no resistance, the endeavour will be the same. For simply to endeavour is to go" [Hobbes (1655), III.22, art.1, p. 333]. Second, it must be noticed that the definition of "pressure" is given in reference to the behaviour of the patient. If the latter, "either all or part", does not "go out of its place" we cannot talk of pressure. Pressure, let us remember, is one of the actions considered in reference to the effects it has on the patient.

The second type of action relevant from the point of view of its effects is resistance. "I define resistance to be the endeavour of one moved body either wholly or in part contrary to the endeavour of another moved body which toucheth the same" [Hobbes (1655), III.15, art.2, p. 211]. First of all, let us note that resistance is as much "endeavour" as pressure is. In this sense there is no qualitative difference. Resistance, then, is, like any form of endeavour, motion "without considering its quantity". This means that resistance is not simply obstacle to other motion but "active power." Second, this endeavour is "contrary" to another endeavour, namely, to the "endeavour of another moved body which toucheth the same." And "contrary" means, precisely, in opposite direction. We can talk, however, of two kinds of resistance regarding its direction: "wholly contrary" and "contrary in part". "I say, wholly contrary, when the endeavour of two bodies proceeds in the same strait line from the opposite extremes, and contrary in part, when two bodies have their endeavour in two lines, which, proceeding from the extreme points of a strait line, meet without the same" [Hobbes (1655), III.15, art.2, p. 211]. And, thirdly, another important consequence follows from the definition of resistance: if resistance is motion, then not only (a) a body in motion will "resist more" than a body at rest, but (b) a body in "wholly contrary" motion will re-

sist even more than a body "contrary in part". These two last conclusions are in opposition to Descartes' idea of resistance. And Hobbes is aware of it. Although the latter does not mention the French philosopher, somewhere else in *De Corpore*, Hobbes writes:

> There is one that has written that things moved are more resisted by things at rest, than by things contrarily moved; for this reason, that he conceived motion not to be so contrary to motion as rest. That which deceived him was, that the words rest and motion are but contradictory names; whereas motion, indeed, is not resisted by rest, but by contrary motion. [Hobbes (1655), II.10, art.7, p. 125]

Descartes could have been the author referred to as "one who has written" those things. In fact, in Descartes' *Principles of Philosophy* (Lat. 1644), art.44, we read: "Que le mouvement n'est pas contraire à un autre mouvement, mais au repos; et la détermination d'un mouvement vers un côté, à sa détermination vers un autre" [Descartes (1644), pp. 194-5].[12] However, assuming that Hobbes is referring to Descartes, his criticism is not totally well-founded. Descartes' idea of rest, in fact, implies a "force of rest" [Descartes (1644), 46, pp.193-4][13] and, therefore, for Descartes to say that the body at rest offers resistance is to say that the object at rest exercises a force against the agent. Now, is this enough to protect Descartes's words from Hobbes' criticism? No, because even though the French also attributes a force ("endeavour" in Hobbes' terms) [Hobbes (1655), III.15, art. 2, p. 212][14] to the body which resists (like Hobbes), he does not draw what seems to be a natural consequence of this view, namely, that a contrary motion (i.e. a contrary force) would offer more resistance than a body simply at rest (even if this implies force too). In fact he says explicitly the opposite, as we have seen above.

There is another related major novelty in Hobbes' reasoning with respect to Descartes. Whereas the latter is deriving the consequences for the idea of "resistance" and "action against another body" from his first law only, Hobbes is introducing a new factor in the issue: the direction of the movement. From the first law — that everything remains in its state of motion or rest unless something acts on it — Descartes concludes that everything "acts against another body or resists its action in so far as it remains in its state" of rest or motion [Descartes (1644), 43, p. 193, see note 13]. Thus resistance is equal to inertia, the force which maintains the body in its state. And the direction of that force (resistance) is independent of the action of another agent on that particular body. Hobbes, by introducing directionality as a relevant factor, can "classify" resistance (or resistant motions) according to their directions with respect to the original action, being "contrary motion" (i.e. opposite motion) the most resistant — if we do not take into account, of course, the degree of intensity of the "endeavour"). And this allows to con-

clude that reaction, in its strict sense, is in Hobbes only one kind of resistance: resistance which is "wholly contrary" to the action exerted on it.

But let us see —before continuing the discussion on resistance— the third type of action with respect to its effects on the moved object: restoration. "A body which is pressed and not wholly removed, is said to restore itself when, the pressing body being taken away, the parts which were moved do, by reason of the internal constitution of the pressed body, return every one into its own place" [Hobbes (1655), III.15, art.2, p. 211]. Given this definition, is restoration different from resistance? Not if we consider the nature of the motion, but the point of view and the scope of that motion are. Restoration is, on one hand, one of the consequences of resistance. Furthermore, it is the only observable consequence of the action of the "force within" the body acted on after the pressure on it is over. Whereas all bodies may resist motion, not all bodies experience restoration. The endeavour which resists the pressure may have, only in some cases ("in springs, in blown bladders, and in many other bodies") as a result the "return" of its parts to their original place. And this is due to "the internal constitution of the pressed body" [Hobbes (1655), III.15, art.2, p. 211][15].

Now, can we call Hobbes' "resistance," sometimes expressed as "restoration", reaction as I have suggested above? If we take "reaction" in its simple sense of action of a body against (i.e. in contrary direction) the action (or pressure) of a body exercised upon the former, then, yes, we can talk of reaction in Hobbes. In fact, later on in *De Corpore*, where the above ideas on action are developed, Hobbes himself uses the term reaction to refer to both resistance and restoration — he had not used, however, the term reaction explicitly in the definitions of these actions, as we have seen above. He applies this term to resistance in the fourth part of the book: "All resistance is endeavour opposite to another endeavour, that is to say, reaction" [Hobbes (1655), IV.25, art.2, p. 391]. And as to restoration he seems to be using it as a synonym of reaction in the following fragment:

> Action and reaction proceed in the same line, but from opposite terms. For seeing reaction is nothing but endeavour in the patient to restore itself to that situation from which it was forced by the agent; the endeavour or motion both of the agent and patient or reagent will be propagated between the same terms; yet so, as that in action the term, from which, is in reaction the term to which. And seeing all action proceeds in this manner, not only between the opposite terms of the whole line in which it is propagated, but also in all the parts of that line, the terms from which and to which, both of the action and reaction, will be in the same line. Wherefore, action and reaction proceed in the same line, & c. [Hobbes (1655), III.22, art.19, p. 348]

The meaning of 'restoration' in this fragment, however, seems to have a wider scope than the one assigned to it by the definition discussed above. It

includes now also the idea of resistance. Restoration is, in fact, considered a form of resistance, which means that the term reaction is referring here to both resistance and restoration. Now, if we accept this, we find in this fragment also a new important precision regarding the concept of restoration — only implicit in the discussion so far. If resistance is "contrary", and restoration is a "return to the original position", and restoration is also a form of resistance, then we can say that restoration is, more specifically, action in contrary direction ("in the same line"). We have seen before that the qualifications "contrary" or "wholly contrary", in the sense of direction, were only applied to resistance, not to restoration.

Now, if reaction is taken in the even more strict sense of a contrary and equal endeavour then we cannot say that we find this in Hobbes. We do, of course, in Newton: "LAW III. To every action there is always an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts" [Newton (1966), II, p. 13]. But Hobbes is, in any case, and despite the general impression current among some scholars, closer to this law than to the law of inertia — from which, as we have seen, he is separated in two important aspects (the requirement of having infinite motion and in a straight line). Furthermore, whereas the main requirements missing in Hobbes in order to defend the law of inertia are crucial ones, with cosmological and even metaphysical implications, the missing requirement to have the law of action and reaction — i.e, that the contrary action must be equal to the originally action — does not seem to have similar consequences. Not only this absence does not imply in Hobbes' natural world any important differences with respect, say, to Newton's world, but it can be said that, in fact, Hobbes' view of the natural world seems to support the view that the reaction takes place as Newton's third law later on would enunciate. And this is so for the following reason. We have seen that, according to Hobbes, motion is coeternal with the world. Now, it is also true for Hobbes that no matter how small that motion might be it still will convey motion. On one hand, Hobbes says, "When a point is at rest, if it do not yield to the least impetus, it will yield to none; and consequently it will be impossible that that, which is at rest, should ever be moved"; and, on the other, "when a point moved, how little soever the impetus thereof be, falls upon a point of any body at rest, how hard soever that body be, it will at the first touch make it yield a little" [Hobbes (1655), III.15, art.3, pp. 212-3].[16] We can conclude, then, that there is no loss of motion –otherwise there would be a smallest action without a corresponding reaction-- or, at least, no reason for it.[17] And if there is no loss, if there is always motion conveyed by the agent to the patient, there is no reason why the reaction would not be equal to the action –given, of course, that there is even less reason to expect an increase.[18]

It is worth noting also the remarkably strong Hobbesian taste of Newton's own explanation of the third law:

> Whatever draws or presses another is as much drawn or pressed by that other. If you press a stone with your finger, the finger is also pressed by the stone. If a horse draws a stone tied to a rope, the horse (if I may so say) will be equally drawn back towards the stone; for the distended rope, by the same endeavour to relax or unbend itself, will draw the horse as much towards the stone as it does the stone towards the horse, and will obstruct the progress of the one as much as it advances that of the other. If a body impinge upon another, and by its force change the motion of the other, that body also (because of the equality of the mutual pressure) will undergo an equal change, in its own motion, towards the contrary part. The changes made by these actions are equal, not in the velocities but in the motions of bodies; that is to say, if the bodies are not hindered by any other impediments. For, because the motions are equally changed, the changes of the velocities made towards contrary parts are inversely proportional to the bodies. [Newton (1966), II, pp. 13-4]

Leibniz's view of reaction, given about seven years after the publication of the Principia, does not either differ much from Hobbes'. "We can say that when bodies collide, each one is affected only by its own elasticity, caused by the motion which is already in it" [Leibniz (1695), p. 20].[19]

If this reading of Hobbes' understanding of the force of reaction is correct, we can say that he is to be credited for undertaking the second major step in the evolution of the conception of action since Aristotle and for accomplishing, thus, the definite rejection of that conception. Philoponus undertook in the sixth century the first clear step towards this rejection by attacking the Aristotelian principle that an agent in contact with the patient is necessary to both originate and mantain the motion and placing an active principle (the impressed force) in the object moved in order to explain its motion.[20] Thus, for Philoponus the arrow keeps on moving, not because of the medium, as Aristotle thought (since that is the only body in contact with the object being moved),[21] but because "some corporeal motive force has been imparted" in it [Cohen and Drabkin (1948), p. 223].[22] And, similarly, the cause which originates the fall of a body is not the removal of the impediment or the creator of that body, which was Aristotle's explanation [Aristotle (1980), 8.4. 256a36-40],[23] but, again, the active principle in the body [Philoponus (1991), 679, 28 f.].[24] And one thousand years later, in the seventeenth century, Hobbes completed this break with Aristotle's doctrine on action by exploring in detail something forgotten in Antiquity: the effects of the action in the patient. As we have seen, the patient, according to Hobbes's view, just by being patient (i.e. by suffering the action of another body), is also an agent acting in direction contrary to the one the body acting on it has. This idea is not present in Philoponus, for whom the patient, say the arrow, could indeed become the agent of its own motion (after a force has been impressed by the projector in it) but it would become so only in the direction of the motion of the agent,

not against it. Furthermore, resistance for Philoponus was only passive impediment, no active "endeavour" [Philoponus (1991), 682, 8-18].[25]

Is it, however, true that the object moved had never before been conceived as exercising a reaction, except, as Aristotle understood it, in cases of alteration [Aristotle (1955), 1.6, pp. 162-329]?[26] There are good indications that this is not the case. I will give two examples. In twelfth-century Muslim Spain, Ibn Bajja, known in the West as Avempace, wrote in his Comentary in arabic:

> When mover A moves B in a non-natural motion, then B also moves A, but the force of A exerted on B is stronger than the force from B on A, otherwise A would not move B. The force which A exerts diminishes (is subject to fatigue) for two reasons: 1) because A is moved by B, i.e. B exerts a force on A, and 2) because of the fatigue any force is subject to by itself. [*Com. In Phys*. 140 ,8-142, 10 and 142, 10-144 ,16, in Ibn Bajja (1994), pp. 541-3; my italics].

Avempace is, thus, defending here that the object which is moved "exerts a force on" the moving object. This still quite unknown fragment is, as far as I know, the earliest defense of a certain idea of reaction with important similarities to the modern one.[27] And a history of this concept should undoubtedly credit Avempace with the change from a view of the patient as resistance merely insofar as it is obstacle to a view in which the patient offers resistance by exerting a force on the agent. Notice, however, as it is clear in the above quote from Avempace's commentary, that any force exerted by the agent is also by itself subject to "fatigue" — i.e. is being extinguished naturally. This obviously reduces the relevance of the patient's reaction to being one factor of resistance among two — of which the second factor (natural fatigue) always affects the action of the agent no matter whether the first is present or not.

In 1551, about sixty years before Galileo's first mature works and one century before the publication of Hobbes' *De Corpore*, Domingo de Soto, also in Spain, wrote:

> We can find out the cause why we throw a [large] stone, in proportion to our forces, with more violence, and to a longer distance, than a smaller one. The cause is, I think, that wherever there is a lesser resistance, there is also less capacity to receive the impression of the impetus; the forces exercised do not find a body in which they can expand completely. It is equally the cause why a feather does not fly with as much impetuosity [as a stone]; furthermore it is not equally adapted to traverse the medium. [28]

Soto is here trying to solve a problem pending since Aristotle: why a larger or a heavier stone reaches a further distance under the same conditions. This should not be the case if, as Aristotle explained, the medium is the

cause, on one hand, and the force of the arm is the same in both cases, on the other. Against the standard explanation at the time — given in the name of the impetus, force, or endeavour impressed in the body — Soto is saying here that the distance is directly proportional to the resistance of the body, not inversely proportional to the resistance of the medium as Aristotle, first, and all the defendants of the impetus theory, later, would say. Now, if the distance covered by the projectile is also proportional to the impetus impressed in it,[29] then we have that Soto is equating, at least as factors of velocity, both impetus and resistance of the body. They both increase velocity. Soto does not say, however, that this resistance is an action of the body contrary to the one exercised on it. But this step requires a lesser demand than the one already taken by Soto — the one in which he makes resistance directly proportional to the velocity. Not only that but it could also be argued that the Newtonian view of reaction is the only possible way in which that resistance could be understood if we wanted to preserve the consistency with Soto's premises. Soto might not, however, have been willing to answer affirmatively if asked about whether he would consider the resistance of the object moved an action. Hobbes would have said yes, as we have seen.

II. Reaction in the Human Body

Hobbes uses the term "reaction" more openly and directly when talking about perception than when talking about locomotion — probably because in the latter case he was interested in the distinction between resistance and restoration rather than in their similarities, as becomes clear at the end of *De Corpore*. In this book Hobbes gives the following definition of sense: "Sense is a phantasm made by the reaction and endeavour outwards in the organ of sense, caused by an endeavour inwards from the object, remaining for some time more or less" [Hobbes (1655) IV.25, art.2, p. 391; Hobbes' italics]. Thus reaction is not only part of the process of perception: it plays a crucial role in it. The reaction of the organ is the real cause of it, and not the original action on it. This means that sensations are not, strictly speaking, impressions on the body but expressions of it. Four years before, in *Leviathan* (1651), Hobbes used the term "counter-pressure" and "resistance" to express a similar idea [Hobbes (1651), pp. 1-2].[30] The terms, however, were not so clearly mechanical a bit earlier in *The Elements of Law* (1650): "Originally all conceptions proceed from the action of the thing itself, whereof it is the conception: now when the action is present, the conception it produceth is also called sense; and the thing by whose action the same is produced, is called the object of the sense" [Hobbes (1650), ch. II.2, p. 3]. This makes one think that Hobbes could have been updating his psychological views at the same time he was modifying his own natural explanations.

From Hobbes' physical views we know that reaction follows to action. But why does sensation take place in the moment of reaction and not of action? Well, on one hand, the result of the action or pressure on the organs must be, in fact, a reaction, as we have seen above. Like in any other physical body, "seeing, therefore, there is in the whole organ, by reason of its own internal natural motion, some resistance or reaction against the motion which is propagated from the object to the innermost part of the organ, there is also in the same organ an endeavour opposite to the endeavour which proceeds from the object" [Hobbes (1655), IV.25, art.2, p. 391]. So far there seems to be just a clear correspondence between the idea of reaction in the organs of perception and the one we saw in the natural world. But Hobbes adds at this point another reason why sensation is a reaction and not an action: "when that endeavour inwards is the last action in the act of sense, then from the reaction, how little soever the duration of it be, a phantasm or idea hath its being; which, by reason that the endeavour is now outwards, doth always appear as something situate without the organ" [Hobbes (1655), IV.25, art.2, p. 391]. The reason why this should be so —why an "endeavour outwards" should produce a phantasm whose being is "without the organ"— is not clear here and it seems to reside in the nature of our sense organs, which are generators of phantasms [Hobbes (1655), IV.25, art.4, p. 392].[31] That nature, however, is not part of Hobbes' inquiry.

III. Reaction in the Social Body

The state of war among men is a state of unnatural (uncontrollable) reactions. "During the time [they] live without a common power to keep them all in awe, they are in that condition which is called war; and such a war, as is of every man, against every man" [Hobbes (1651), p. 113]. In such a state, man lives in fear of the reactions of other citizens, especially in fear of death. "The passions that incline men to peace, are fear of death; desire of such things as are necessary to commodious living; and a hope by their industry to obtain them" [Hobbes (1651), I.13, p. 116]. And, therefore, he searches for peace, for a natural order in society where he can carry his life without the resistance (i.e. the reactions of others) which sets his life in danger, and where he can enjoy happiness. However, even in the peaceful "kingdom of God" the citizen's actions may encounter the reaction of the state when his actions are contrary to the well-being of society, that is to the law, that is to the preservation of the state [Hobbes (1655), II.28, p. 297].[32] The state in turn may encounter the reaction of the citizen when the latter, in self-defense, decides to preserve his own life (his inertial natural motion) in front of Leviathan [Hobbes (1651), II.21, p. 204].[33]

It is interesting here to observe not simply the presence of reactions in multiple directions, but how Hobbes seems to be using a double idea of reaction in the socio-political context: a natural and an unnatural concept. The state of war is not, properly speaking, a system of actions and reactions, where the latter are actions contrary to the former (which restore their effects and thus contribute to preserve the social body itself). This cannot be the case because, properly speaking, for Hobbes, reactions are not chaotic; they respond to certain laws of nature which, by definition, preserve the natural state. And what is natural in society (once it has been constituted) is, similarly, that which contributes to its preservation. And in so far as it does so, it is necessary and just. Thus, it is natural, and, properly speaking, a necessary reaction by the state, to punish crime because it is an action against the preservation of society. And it is equally natural for the individual to react against those, included the sovereign, who attempt to rid him of "any thing without which he cannot live", that is, it is natural for the individual to act in self-defense of his life. This is the reason why both actions — the state's against the criminal and the citizen's against the state in self-defense — are just: "Upon this ground, a man that is commanded as a soldier to fight against the enemy, though his sovereign have right enough to punish his refusal with death, may nevertheless in many cases refuse without injustice" [Hobbes (1651), p. 205; my italics]. The extreme case of conflict, of maximum reaction, would be represented, like in the natural world, by two just (i.e. self-preserving) and "wholly contrary" actions, that is, two simultaneous contrary actions acting against the existence of the other agent. And we can still say that these confrontations, unlike those in the state of war, are as natural in society as the pressure suffered by the finger which is pressing the stone is in the natural world.

CONCLUSION

In Hobbes' materialistic world view there is nothing but matter and motion, where motion means, specifically, locomotion. To talk about reaction in such a world, then, can only mean to talk about bodies re-acting to the action of other bodies, that is motion of bodies against (or contrary to) the motion of other bodies. Hobbes believed that, indeed, as long as there is action in nature — that is, action of matter on matter — there is a resulting reaction (instead of the latter term, however, Hobbes prefers quite often to use "resistance" and "restoration").[34] Thus, a more precise view of Hobbes' world would be to say that it is made, not simply of matter and motion, or matter and locomotion, but of matter, action, and reaction. And this is valid, as in so many other cases in Hobbes's philosophy, not only for the physical realm but also for the physiological and social ones.

Much of the originality of Hobbes' thought has been found so far in his ability to bring the lessons drawn from the study of the natural world into the psychological and social ones. Many of his main social ideas, if not all, in fact, were first defined in physical terms. The idea of reaction — quite forgotten in the secondary literature — may be seen also as one of those physico-psycho-social ideas, and in this sense I am simply adding something to the side of those who see an underlying unity in Hobbes' philosophy. However, in this case, we can say that Hobbes is not simply applying physical ideas to other domains but developing an original idea which deserves a distinguished place in the history of Newton's third law of motion. And the fact that this idea is clearly and explicitly applied by himself to his own biological and social thought does more than just support the unifying view of his philosophy. It also indicates that it is not a marginal one or one he unexpectedly or unconsciously supported, but a mature one in his thought. Although I have only sketched the biological and political versions of reaction, I think that it may offer the possibility of a new reading of some of Hobbes's most celebrated passages on sensation and society.

Hobbes' idea of reaction completed the one given by Descartes in his Principles of philosophy. From his first law of motion, Descartes concluded that "resistance" and "action against another body" were just two ways of talking about the inertia of a body. Hobbes, who did not defend the law of inertia in Cartesian terms, added to the resistance offered by the bodies's tendency to continue "in the same way" (he does not say in a straight line when they are in motion) the role of directionality, and corrected Descartes for missing it. For Hobbes reaction in the physical world is an action of the patient which occurs as soon as, and as long as, it becomes patient of another body's action. In other words, any body, as long as it s acted on, reacts. And if the patient is already in motion that reaction will be maximized when, if everything else remains the same, the direction of the resistant (or reacting) body is "wholly contrary" to the direction of the agent.

Hobbes' idea of reaction represents what could be considered the culmination of the second main historical stage in the revision of the Aristotelian conception of action. The first stage affected the view of the agent and was undertaken by Philoponus, who rejected the necessity of contact between agent and moved, and attributed the motion of a projectile to an impressed force. The second stage of that revision affected the view of the patient. Avempace, in the twelfth century, was probably the first — according to what is known so far — who talked in the West of an action exerted by the patient on the agent. Avempace, however, (1) did not talk about an equal reaction of the moved object, (2) did not mention anything about whether that reaction is applied in an opposite direction (to the action of the agent), and, unlike Hobbes, Newton or Leibniz, (3) defended, together with his idea of reaction, that the force applied by the agent does not need that reaction or the

medium in order to diminish — because the second factor of fatigue is always present, that is, the fatigue that affects any force, whether it encounters resistance (or a force from the moved object) or not. Hobbes' view of reaction differed from Newton's, explicitly, only in the idea that the reaction is equal to the action — which is not present in Hobbes. But if we focus on Hobbes' use of the idea, that difference is not so obvious.

Hobbes further developed the idea of reaction, where he distinguished resistance from restoration, a distinction absent in both Descartes and Newton. And he applied his idea of reaction to his theory of perception and his theory of the state. The application to perception assigns a crucial role to reaction; sensation is the reaction of our sense organs. This correspondence, however, is left incomplete because the reaction itself depends on the "nature of the organ" and the details are not studied by Hobbes. On the other hand, the concept of reaction observed within Hobbes' social theory reveals a new meaning in it: now we see that there is natural and unnatural (or chaotic) reaction. Natural reactions are those which preserve the peaceful order of the absolute state (and the life of its citizens) and for that reason these actions are always just. Unnatural reactions are those who break the social order (i.e. those in the state of war or criminal ones under Leviathan) and they are, similarly, unjust.*

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NOTES

[1] "[I]t is manifest that all other accidents besides magnitude or extension may be generated and destroyed [...] and therefore bodies, have this difference, that bodies are things, and not generated; accidents are generated, and not things" [Hobbes (1655), II.8, art.20, pp. 116-7].

[2] This generation and destruction can happen, obviously, only in reference to *this* body and *this* motion; motion in the world is not generated or destroyed.

[3] Motion is also "the measure of time" [Hobbes (1655), III.15, p. 205]. Cf. also Hobbes (1655), II.8, art.16, pp. 113-4.

[4] This is the form the first law of motion had in Descartes: "il n'y a point d'autre raison pourquoy elles [projectiles] continuent [...] de se mouvoir, lors qu'elles sont hors de la main de celui qui les a poussées, sinon que, suivant la loix de la nature, tous les corps qui se meuvent continuent de se mouvoir jusques à ce que leur mouvement soit arresté par quelques autres corps [...]" [Descartes (1644), II.38, p. 85]. Hobbes, however, does not mention Descartes here.

[5] This idea had previously been discussed and defended in Hobbes (1655) II.9, art.7, pp. 124-5. This is Descartes' law II: "La seconde loy que je remarque en la na-

ture est que chaque partie de la matiere, en son particulier, ne tend jamais à continuer de se mouvoir suivant des lignes courbes, mais suivant des lignes droites, bien que plusieurs de ces parties soient souvent contraintes de se détourner, pource qu'elles en rencontrent d'autres en leur chemin et que [...], lorsqu'un corps se meut, il se fait tousjours un cercle ou anneau de la matiere qui est meuë ensemble" [Descartes (1644), II.39, p. 85]. Both Descartes's law I and II will later on be included in Newton's first law of motion (*Principia*, 1687): "LAW I. Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it" [Newton (1966), II, p. 13]. Notice that, unlike Descartes' laws, Newton's refers explicitly to "uniform motion".

[6] See two previous notes for a textual comparison. Neither Descartes nor Newton mention the necessity of a contiguous agent.

[7] And later on Hobbes writes: "all endeavour tends towards that part, that is to say, in that way which is determined by the motion of the movent, if the movent be but one; or, if there be many movents, in that way which their concourse determines. For example, if a moved body have direct motion, its first endeavour will be in a strait line; if it have circular motion, its first endeavour will be in the circumference of a circle" [Hobbes (1655), III.15, art.3, p. 215].

[8] "The immense space, which we call the world, is the aggregate of all bodies which are either consistent and visible, as the earth and the stars; or invisible, as the small atoms which are disseminated through the whole space between the earth and the stars; and lastly, that most fluid ether, which so fills all the rest of the universe, as that it leaves in it no empty place at all" [Hobbes (1655), IV.26, art.5, p. 426].

[9] See the exact words used by Descartes and Newton in notes 5 and 6. Hobbes avoids using "in a straight line" in other places also, for example: "whatever is moved perseveres in the same way and with the same swiftness, as long as it is not hindered by something that is moved against it" [Hobbes (1655), III.15, art.3, p. 213].

[10] Michel Verdon has written, although without offering clear textual evidence, that "Hobbes could be described as standing between Galileo and Descartes, borrowing circular inertial motion from the first and rectilinear from the second" [Verdon (1982), p. 662]. There are, however, indications that of this ambiguity in several of Hobbes' views. He applies, for example, the term "simple" motion both to circular and not circular motion. And both circular and not circular motion can be perpetual [Hobbes (1655), III.21, art.1, pp. 317-8 and art.3, pp. 321-2]. He does distinguish, though, "direct motion" and "circular motion" by their "first endeavour". Whereas the endeavour of the former "will be in a strait line", the endeavour of the latter will be "in the circumference of a circle" [Hobbes (1655), III.15, art.3, p. 215]. Hobbes considered also the possibility of motion along an infinite distance ("all endeavour, whether strong or weak, is propagated to infinite distance; for it is motion" [Hobbes (1655) III.15, art. 7, p. 216]) even though he neither affirms nor the infinitude of the world [Hobbes (1655), IV.26, art.1, p. 414].

[11] Hobbes explains: "Endeavour is to be conceived as motion; but so as that neither the quantity of the time in which, nor of the line in which it is made, may in demonstration be at all brought into comparison with the quantity of that time, or of that line of which it is a part" [Hobbes (1655), III.15, art.2, p. 206].

[12] And this is the explanation which accompanies this article: "Il faut remarquer qu'un mouvement n'est pas contraire à un autre mouvement plus vite que soi, et qu'il

n'y a de la contrariété qu'en deux façons seulement. A savoir, entre le mouvement et le repos, ou bien entre la vitesse et la tardiveté du mouvement, en tant que cette tardiveté participe de la nature du repos; et entre la détermination qu'a un corps à se mouvoir vers quelque côté, et la résistance des autres corps qu'il rencontre en son chemin, soit que ces autres corps se reposent, ou qu'ils se meuvent autrement que lui, ou que celui qui se meut rencontre diversement leurs parties; car, selon que ces corps se trouvent disposés, cette contrariété est plus ou moins grande" [Descartes (1644), II.44, pp.194-5].

[13] "Outre cela il faut remarquer que la force don't un corps agit contre un autre corps ou résiste à son action, consiste en cela seul, que chaque chose persiste autant qu'elle peut à demeurer au même état où elle se trouve, conformément à la première loi qui a été exposée ci-dessus. De façon qu'un corps qui est joint à un autre corps, a quelque force pour empêcher qu'il n'en soit séparé; et que, lorsqu'il en est séparé, il a quelque force pour empêcher qu'il ne lui soit joint; et aussi que, lorsqu'il est en repos, il a de la force pour demeurer en ce repos et pour résister à tout ce qui pourrait le faire changer. De même que, lorsqu'il se meut, il a de la force pour continuer de se mouvoir avec la même vitesse et vers le même côté" [Descartes (1644), II.43, pp. 193-4].

[14] Hobbes reserves the term force for what was called at the time *vis viva*: "I define force to be the impetus or quickness of motion multiplied either into itself, or into the magnitude of the movent, by means whereof the said movent works more or less upon the body that resists it" [Hobbes (1655), III.15, art. 2, p. 212].

[15] "This we may observe in springs, in blown bladders, and in many other bodies, whose parts yield more or less to the endeavour which the pressing body makes at the first arrival: but afterwards, when the pressing body is removed, they do, by some force within them, *restore* themselves, and give their whole body the same figure it had before" [Hobbes (1655), III.15, art.2, pp. 211-2].

[16] "When a point is at rest, if it do not yield to the least impetus, it will yield to none; and consequently it will be impossible that that, which is at rest, should ever be moved./ "Secondly, when a point moved, how little soever the impetus thereof be, falls upon a point of any body at rest, how hard soever that body be, it will at the first touch make it yield a little. For if it do not yield to the impetus which is in that point, neither will it yield to the impetus of never so many points, which have all their impetus severally equal to the impetus of that point" [Hobbes (1655), III.15, art.3, pp.212-3].

[17] That there is a loss of motion in the process had somehow been assumed since Aristotle's explanation of projectile motion. The "successive secondary agents" (i.e. parts of air) convey less and less "power of conveying motion" to the following one, which *explains* why the arrow eventually stops. But Aristotle does not say why this loss should occur. "We are forced to suppose that the prime mover conveys to the air (or water, or other such intermediary as is naturally capable both of moving and conveying motion) a power of conveying motion, but that this power is not exhausted when the intermediary ceases to be moved itself. Thus the intermediary will cease to be moved itself as soon as the prime mover ceases to move it, but will still be able to move something else. Thus this something else will be put in motion after the prime mover's action has ceased, and will itself continue the series. The end of it all will approach as the motive power conveyed to each successive secondary agent wanes, till at last there comes one which can only move its neighbour without being able to convey motive force to it. At this point the last active intermediary will cease to convey

motion, the passive intermediary that has no active power will cease to be in motion, and the missile will come to a stand, at the same instant. Now, this movement occurs in things that are sometimes in motion and sometimes stationary, and it is not continuous, though it appears to be. For there is a succession of contiguous agents, since there is no one motor concerned but a series, one following upon another. And so there comes about both in air and water the kind of motion that some have called *antiperistasis*" [Aristotle (1980), 8.10. 266b27-267a22].

[18] This does not mean, however, that Hobbes believed that both *motions* (the agent's and patient's) are equal: "moment is the excess of motion which the movent has above the motion or endeavour of the resisting body" [Hobbes (1655), III.15, art.5, p. 214].

[19] "I find that in nature it is necessary to employ not only the notion of extension but also that of force, which makes matter capable of acting and of resisting. By 'force' [...] I mean something midway between power and action, something which involves an effort, an act, an entelechy — for force passes into action by itself as long as nothing prevents it. That is why I consider it [force] to be what constitutes substance, since it is the principle of action, which is its characteristic feature." [Leibniz, (1694), p. 22]

[20] An agent in contact is necessary for two reasons: a) to initiate the motion: "Taking the initiator of movement to mean not that for the sake of which the movement takes place, but that which sets it going, we may say that the initiator must be in direct touch with the thing it immediately moves; and by this I mean that there can be nothing between them. This is true of every mover and the moved it directly acts upon" [Aristotle (1980), 7.1. 243a3-11]; and b) to maintain the motion (e.g. to keep the arrow in motion): "If a thing is in motion it is, of necessity, being kept in motion by something" because "if it [the mobile] has not the source of its motion within itself, then it is clear enough that is being moved by something else, for what moves it will be a second thing" [Aristotle (1980), 7.1. 241b34].

[21] "We are forced to suppose that the prime mover conveys to the air (or water, or other such intermediary as is naturally capable both of moving and conveying motion) a power of conveying motion, but that this power is not exhausted when the intermediary ceases to be moved itself." [Aristotle (1980), 8.10. 266b27-267a22].

[22] "But the fact is that even if you place the arrow or stone upon a line or point quite devoid of thickness and set in motion all the air behind the projectile with all possible force, the projectile will not be moved the distance of a single cubit. [...] It is necessary to assume that some incorporeal motive force is imparted by the projector to the pojectile, and that the air set in motion contributes either nothing at all or else very little to this motion of the projectile" [John Philoponus, *Commentary on Aristotle's Physics*, pp. 639.3-642.9, in Cohen and Drabkin (1948), p. 223].

[23] "Light and heavy substances are moved either directly by what agent soever generates them and makes them light or heavy, or incidentally by the agent that removes the obstruction or hindrance" [Aristotle (1980), 8.4. 256a36-40]. To the idea of the removal of the obstacle as *cause* Hobbes had answered explicitly: "They are therefore deceived, that reckon the taking away of the impediment or resistance for one of the causes of motion" [Hobbes (1655), III.15, art.3, p. 213].

[24] "Weight and lightness do not belong to the things that have them because of something other than themselves, and weight is an active cause of downward motion,

and lightness of upward motion, whenever things that have weight or lightness are in the place that is contrary to their nature and there is nothing obstructing their motion" [Philoponus (1991), 679, 28 f.].

[25] "And if you thin the bodily medium to infinity, you will lessen to infinity the time taken for parting the bodily medium — I mean the one hour — but you will never exhaust it. For time is divisible to infinity." [Philoponus (1991), 682, 8-18].

[26] "We must suppose that the same account holds good of "action" and "passion" as about moving and being moved. For "move" is also used in two senses; for that in which the original source of motion resides is generally held to cause motion (for the original source is the first of causes), and so also is that which is last in relation to that which is moved and to the process of coming-to-be. Similarly, too, in the case of the agent; for we speak of the doctor, and also of wine as healing. Now, in motion, there is nothing to prevent the first mover being unmoved (in fact in some cases it is actually necessary), but the last mover always causes motion by itself being moved; and in action, there is nothing to prevent the first agent being unaffected, but the last agent is itself also affected. For those things which have not the same matter act without being themselves affected (for example, the art of the physician which, while it causes health, is not itself acted upon by that which is being healed), but food, while it acts, is itself all somehow acted upon, for, while it acts, it is at the same time being heated or cooled or affected in some other way. Now the art of the physician is, as it were, an original source, while the food is, as it were, the final mover and in contact with that which is moved." / "Of the things, then, which are capable of acting, those of which the form does not consist in matter are not affected, but those of which the form consists in matter are liable to be affected; for we say that the matter of either of the two opposed things alike is the same, so to speak, being, as it were, a kind; and that which is capable of being hot must become hot, if that which is capable of heating is present and near to it [...]". [[Aristotle (1955), 1.8].

[27] Cf. Pines (1964), pp. 462 and 468. In order to suuport that there is a "certaine similitude entre Leibniz et Ibn Bajja en ce qui concerne la transformation que subi chez l'un et chez l'autre la notion péripatéticienne de *dynamis"* [Pines (1964), p. 468], pines refers to Leibniz's concept of force, as expressed in Leibniz, (1694), p. 22: "By 'force' or 'potency' I do not mean a power or a mere faculty, which is only a bare possibility (*une possibilité prochaine*) for action and which, being itself dead as it were, never produces an action without being excited from outside; instead I mean something midway between power and action, something which involves an effort, an act, an entelechy — for force passes into action by itself as long as nothing prevents it".

[28] Domingo de Soto, *Super octo libros Physicorum Aristotelis Quaestiones* (Salamanca: In aedibus Dominici a Portonariis, Cath. M. Typographi, 1572), fol.101, col.*a*; quoted in P. Duhem (1913), pp. 281-2.

[29] Soto defended the theory of *impetus* although, somehow surprisingly, he tried to reconcile it with Aristotle's necessity of the medium: "the air is not the only cause which moves the projectile; he who throws the projectile is also the cause, by mediation of the *impetus* that it has impressed in the projectile" [Soto, *Quaestiones*, fol. 100, col. *c.* y *d.*, in Duhem (1913), p. 281]. However, Aristotle clearly defends that the velocity is inversely proportional to the resistance of the medium: "The velocity of a moving weight or mass depends on two conditions: (1) the distinctive nature of the medium — water, earth, or air — through which the motion occurs, and (2) the

comparative gravity or levity of the moving body itself, other conditions being equal" [Aristotle (1980), 4.8. 215a25-28].

[30] "The cause of sense, is the external body, or object, which presseth the organ proper to each sense, either immediately, as in the taste and touch; or mediately, as in seeing, hearing, and smelling; which pressure, by the mediation of the nerves, and other strings and membranes of the body, continued inwards to the brain and heart, causeth there a resistance, or counter-pressure, or endeavour of the heart to deliver itself, which endeavour, because *outward*, seemeth to be some matter without. And this *seeming*, or *fancy*, is that which men call *sense*" [Hobbes (1889), pp.1-2].

[31] "The organs of sense, which are in the sentient, are such parts thereof, that if they be hurt, the very generation of phantasms is thereby destroyed, though all the rest of the parts remain entire. Now these parts in the most of living creatures are found to be certain spirits and membranes, which, proceeding from the *pia mater*, involve the brain and all the nerves; also the brain itself, and the arteries which are in the brain: and such other parts, as being stirred, the heart also, which is the fountain of all sense, is stirred together with them" [Hobbes (1655), IV.25, art.4, p. 392].

[32] "A punishment is an evil inflicted by public authority on him that hath done, or omitted that which is judged by the same authority to be a transgression of the law; to the end that the will of men may thereby the better be disposed to obedience" [Hobbes (1655), II.28, p. 297].

[33] "If the sovereign command a man, though justly condemned, to kill, wound, or maim himself; or not to resist those that assault him; or to abstain from the use of food, air, medicine, or any other thing, without which he cannot live; yet hath that man the liberty to disobey" [Hobbes (1651), II.21, p. 204].

[34] Neither of these terms (reaction, resistance, and restoration) are part of the vocabulary compiled in Martinich (1995).

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