

Toward a BFO-Based Deontic Ontology

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ABSTRACT

This paper discusses four candidate ways of categorizing constraint-oriented deontic entities such as *obligation*, *claim*, *permission*, *prohibition*, *immunity*, and *right* within the framework of Basic Formal Ontology: (1) *relational quality*, (2) *role*, (3) *socio-legal generically dependent continuant* (Document Acts Ontology), and (4) *directive information entity* (Information Artifact Ontology). Its principal thesis is that such entities are best categorized as species of *directive information entity*. After considering each candidate, rejecting the first three, and endorsing the fourth, the paper concludes with some preliminary discussion of how to define *obligation* as a subtype of *directive information entity*, namely, as a *directive information entity* that is issued with normative authority.

1 INTRODUCTION

Recent research in biomedical information systems recognizes the need for ontologies to formally represent deontic entities and their relationships, e.g., a health-care professional's obligations to her patients, a patient's claim to information requisite for consent, the relationship between a health-care professional's obligation and a patient's claim on that professional, a surgeon's permission to bring a patient under the knife, a husband's power to make proxy decisions for his incapacitated wife, a hospital administrator's authority over her staff, a patient's immunity from coercion, institutional norms and policies, or any of the details of federal, state, and local health-care law (Almeida, *et al.*, 2012; Brochhausen, *et al.*, 2013; Dumontier, *et al.*, 2014; Lin, *et al.*, 2014; Lin, *et al.*, 2016; Smith, 2016). The development of a general ontology of deontic entities would be useful to this end since it could be reused not only within particular biomedical ontologies, but also within other domains of interest, including legal knowledge bases and military doctrine and intelligence.

This paper takes some initial steps toward the development of such an ontology by addressing the question of where to situate the categories of *obligation* and *right* within the context of Basic Formal Ontology (BFO) (Arp, *et al.*, 2015). Its principal thesis is that *right* and *obligation* are best categorized as species of the BFO-based Information Artifact Ontology (IAO) class *directive information entity*. The rest of this paper unfolds as follows. In Section 2, I offer an approximate characterization of the relevant kinds of deontic entity. In Section 3, I introduce BFO's distinction between generic and specific dependence and consider four candidate upper-level categorizations of these deontic enti-

ties, namely, two classes from BFO (*relational quality*, *role*), one from Document Acts Ontology (D-Acts) (*socio-legal generically dependent continuant*), and one from IAO (*directive information entity*). I argue that the first three of these should be rejected and the fourth adopted. I conclude with a few remarks on future work.

2 THE VARIETIES OF DEONTIC ENTITY

An initial step in the development of a deontic ontology is to situate the many varieties of deontic entity into a few intuitive, provisional groupings. One such grouping comprises those entities that concern whether an agent is constrained with respect to some type of action or particular course of action, e.g., *obligation*, *claim*, *permission*, *prohibition*, *immunity*, and *right*. Thus, an obligation (requirement, duty) to perform some action constrains an agent's available courses of action. Obviously the constraint in question is not a restriction upon what is physically possible for the agent. Rather, intuitively an obligation is a constraint upon an action in the sense that it prescribes an action that, were an agent to fail to perform that action, he would (legitimately) be subject to blame or censure. Similar considerations apply to notions like *prohibition*, where the prohibition against doing *X* is a constraint not to perform *X*, or *permission*, where the permission to do *X* is (or at least implies) a constraint against others inhibiting the agent from doing *X*.

Notions such as *rule*, *norm*, and *law* might fall within this first grouping insofar as they are likewise concerned with constraints upon agents' actions. However, at least from the perspective of ordinary language, it might be awkward to group obligations or rights together with laws. The reason is that rights and obligations are in some colloquial sense "had" by agents. By contrast, even if agents are subject to the directives of a law or rule or norm, such entities are not in the same sense "had" by agents. That is not to say that rules, norms, and laws might not in fact be ontologically akin to entities such as rights or obligations. The point is rather, in the interest of orienting this foray into the ontology of deontic entities, to point out that rules, norms, and laws, while likewise concerned with action constraints, might be importantly dissimilar from rights and obligations.

A second grouping of deontic entities comprises abilities to act in ways that have deontic effects, such as (*deontic power* and *authority*). Such entities, when possessed in some sense by agents, enable their bearers to perform acts which

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create, modify, transfer, or eliminate deontic entities identified in the first grouping. Thus, if *A* has authority over *B*, then *A* is able to impose some (though obviously not just any) obligation upon *B*.

A third grouping of deontic entities comprises what can conveniently be called *deontic acts*, i.e., acts such as *promising*, (*authoritatively*) *commanding*, *permitting* (or *consenting*), *waiving*, *loaning*, *lending*, and *selling*. These are acts which realize the deontic abilities of agents and which actually create, modify, transfer, or eliminate constraint-like deontic entities. Such deontic acts have been the subject of discussion in philosophical circles, in particular, in the context of Searle and Reinach's theories of *social acts* (or what Searle calls *speech acts*), especially acts of promising, and their relationship to the emergence of obligations and claims.

The scope of this paper is fairly narrow, in that it only sets out to determine how to best situate the categories of the constraint-like types *right* and *obligation* within the BFO framework—a task which falls short of providing a full account of what rights and obligations are. Before considering four such candidate upper-level categorizations of these entities, I will briefly survey the relevant portions of the BFO class hierarchy.

3 CANDIDATE UPPER-LEVEL CATEGORIES

At its uppermost level, BFO partitions all entities into the categories *continuant* (roughly, three-dimensional entities that persist through time, such as objects and their properties) and *occurrent* (roughly, four-dimensional entities that occur over time, such as processes), the former of which divides in turn into those continuants which have independent existence (*independent continuant*) and two classes of dependent continuants (*specifically* and *generically dependent continuant*). The distinction between *specifically* and *generically dependent continuant* is of particular importance for the purposes of this paper, so I will attempt to spell it out in some detail. (All definitions have been adapted from BFO's axioms.)

Specifically Dependent Continuant =def. A continuant that depends for its existence upon some specific independent continuant.

Generically Dependent Continuant =def. A continuant that depends for its existence upon some independent continuant, but not upon any one in particular.

Suppose, for example, that both *A* and *B* have a headache. Now *A* and *B* do not have the exact same particular headache, even if they suffer ailments of the same type. The reason is that *A*'s headache (that particular headache) depends specifically on *A* (or on his blood vessels, muscles,

nerves, and so forth) in order to exist, whereas *B*'s headache (a different particular headache) depends specifically on *B* in order to exist. *A* cannot have *B*'s headache, and vice versa, nor can *B*'s headache be transferred from himself to *A*.

By contrast, the novel *War and Peace* exists only if there is some copy of *War and Peace* in existence, but its existence is not tied specifically to this or that copy. Thus, the content of *War and Peace* generically depends upon some physical copy, rather than specifically upon some particular physical copy. Consequently, generically dependent continuants are transferable, whereas specifically dependent continuants are not. An electronic document, unlike a headache, can be transferred from one hard drive to another, or to different locations on the same hard drive. In this case, the same particular instance of generically dependent continuant (i.e., the content) endures though the bearer is different.

Given BFO's class hierarchy, I believe that there are four potentially viable candidates for an upper-level categorization of *right* and *obligation*, all of which are subclasses of either *specifically* or *generically dependent continuant*. The candidates are: *relational quality*, *role*, *socio-legal generically dependent continuant* (D-Acts), and *directive information entity* (IAO). In what follows, I argue that *relational quality*, *role*, and *socio-legal generically dependent continuant* are untenable ways of categorizing *right* and *obligation*, and that instead they should be categorized as subtypes of *directive information*.

3.1 Relational Qualities

The first candidate is *relational quality*, a subclass of *quality*, a subclass of *specifically dependent continuant*:

Quality =def. A specifically dependent continuant that, when it exists, needs no process in order to be manifest.

Relational Quality =def. A quality that, when it exists, inheres in multiple bearers.

Significantly, an annotation on *relational quality* suggests that one example of a relational quality is “an obligation between one person and another.” The idea here is apparently that, if *A* is obliged to *B*, then that obligation is a relational quality that inheres multiply in each or in the aggregate of *A* and *B*. This strongly suggests that, at least to the mind of some of BFO's developers, *obligation* should be treated as a subclass of *relational quality*.

There is some initial plausibility behind this suggested categorization. Relational qualities are qualities which co-inhere in multiple bearers and which thus involve relations of “mutual dependence” (Smith, 1993). To use one of BFO's other examples, the existence of a marriage bond depends for its existence upon two specific bearers, namely, the married partners. Thus, John's bearing of this quality depends upon Mary's bearing it, and vice versa. Likewise,

John's obligation to Mary and Mary's claim on John seem to be mutually dependent in this way. Therefore, the line of thought concludes, *claim* and *obligation* are subtypes of *relational quality*.

But this approach is untenable for at least two reasons. First, there is a disparity between the example of being obliged and the example of a marriage bond, namely, that in the cases of marriage the same relational quality plausibly inheres in both bearers, whereas in the case of being obliged, different qualities would inhere in each: an obligation in one and a claim in the other. Even if the obligation and the claim are mutually dependent on one another, such that if one ceases to exist, then the other also ceases to exist, the two would not be identical entities. If a relational quality is a particular that inheres simultaneously in two entities, then one cannot identify that relational quality with a person's claim or another person's obligation without also treating the claim and obligation as identical.

The second, more serious reason why this approach is unsuccessful is that obligations are not necessarily relational in this way. Now cases of relational obligations (A's obligation to B, which correlates to B's claim upon A) are common, but there are also, albeit rare, cases of what Reinach calls "absolute obligations" (*absolute Verbindlichkeiten*), i.e., obligations an agent has which are not obligations to some other person in particular. In other words, it is possible for A to be obliged to do X, but not obliged to B to do X. Thus, Reinach claims, a state "is obliged to certain ways of acting, but this obligation does not exist over against any [specific] persons" (Reinach 1919/1989, 12). In this case, Reinach's point seems to be that this obligation is absolute because it is generic, rather than tied to some specific person (the claimant). Moreover, he notes, it is even possible for B to "impose [*aufuerlegen*]" an absolute obligation on A (if A accepts it) in the absence of any corresponding claim in B. Thus, Reinach offers the example of a German *Auflage* law which states: "The decedent can oblige his heir or legatee to perform a service without letting another acquire a right to this service" (Reinach 1919/1989, 75).

With this distinction in hand, we can see why the relational quality approach falls short. Even if the first difficulty could be resolved, not all obligations could be categorized as relational qualities since not all obligations are relational in this way. Thus, at the very least, the relational quality approach will not, as a general strategy, take us very far.

But there is also another, yet more serious objection to this proposal, which arises from the fact that relational qualities are specifically dependent continuants. Because relational qualities specifically depend on their bearers, relational qualities are necessarily non-transferrable, just as a person's mass or height is non-transferrable. But rights and obligations do seem to be transferrable. For example, if A promises to pick B up from the airport, but afterward delegates this task to C, then the obligation has been transferred

from A to C. If that is correct, then obligations cannot be specifically dependent continuants, and so cannot be relational qualities. Similar considerations apply to the case of rights (e.g., the transference of property rights).

3.2 Roles

Another plausible place to situate *right* and *obligation* is under the category of *role*, which stems from the other main subclass of *specifically dependent continuant*, namely, *realizable entity*. The relevant definitions are:

Realizable Entity =def. A specifically dependent continuant that needs some process in order to become manifest.

Disposition =def. A realizable entity that inheres in a bearer in virtue of that bearer's physical makeup.

Role =def. A realizable entity that inheres in a bearer in virtue of the bearer's circumstances.

Thus, whereas qualities generally are non-dormant properties, whereas realizable entities are (often) dormant properties which become manifest in processes. If the realizable properties are grounded in the intrinsic physical properties of the bearer, then they are dispositions. If they are grounded in the circumstances (whether physical or social) of the bearer, they are roles. For example, a physician could be represented as a person who bears a physician role. Moreover, although being a physician may require possessing certain inherent physical properties—e.g., certain physical or mental capabilities, or a certain degree and type of medical knowledge—a person's role as physician depends also upon some social or legal ratification: graduation from an accredited institution, a license to practice medicine, and so forth.

In this vein, it might be thought that rights and obligations are roles. After all, they seem to be dependent entities—intuitively, there can be no obligation unless there is someone who is obliged—but they also do not seem to be grounded purely in the inherent physical structure of an entity. Rather, they plausibly might be thought to arise in virtue of social or legal convention (e.g., as Searle argues, a collectively accepted social rule that promising counts as putting oneself under an obligation).

Attractive as this view may be, it faces a number of objections. The first is that it commits a category mistake. To see how, consider the pair of statements, 'John has a physician role' and 'John has an obligation role'. Intuitively, the second statement seems to rest on a mistake: a person is not the kind of entity that could have an obligation role. He may be an obligor, but not an obligation.

This first objection gestures toward what might be a broader problem for the Searlean theory of social ontology (Searle, 1995; 2010), on which the BFO class *role* is based.

Searle's social ontology focuses largely on the question of what grounds social and deontic *facts*. At some points, he addresses the question of what social *objects* are, especially what money is. Searle can do so because—at least, prior to the advent of online banking—money can be identified as a physical object (a piece of paper) which has a “status-function” (the social role of being money). Thus, the fact that the dollar bill in my pocket is money is partly constituted by (1) the piece of paper in my pocket and (2) its social role or status-function. In the case of deontic facts, however, there is no obvious physical analogue. That is, there seems to be no tangible object that could be identified as the entity which bears the social role of being an obligation. Rights and obligations may be cases of what Smith calls “free-standing Y terms” (Smith and Searle, 2003), and thus a place where we are pressed to accept the existence of social entities which do not coincide with any physical entity.

A second objection is a reiteration of one we saw previously in the case of relational qualities, namely, that roles are specifically dependent continuants, and thus non-transferrable, whereas rights and obligations do seem to be transferrable. This idea common to both objections, that right and obligations are transferrable, has led to a third candidate upper-level categorization of *right* and *obligation*, namely, that they are species of *generically dependent continuant*. There are, in fact, two relevant proposals. The first of these, proposed in initial versions of D-Acts, treats *right* and *obligation* as *socio-legal generically dependent continuants*. The second, which this present paper endorses, handles them as species of the IAO class *directive information entity*.

3.3 Socio-Legal GDCs

The principal goal of D-Acts (Almeida, *et al.*, 2012; Brochhausen, *et al.*, 2013) is to provide a formal representation of what Smith has called “document acts” (Smith, 2012; 2014), acts such as signing or stamping. Like their speech act counterparts (Searle, 1969), such document acts have “deontic powers”: a contract can create an obligation and a consent form can create the permission to perform a procedure. Thus, to some extent, D-Acts also aims to represent deontic entities such as rights and obligations.

D-Acts does so by defining a class *socio-legal generically dependent continuant* (SLGDC) along with the classes *social act* (following Reinach), *obligor* and *obligee role*:

Socio-Legal Generically Dependent Continuant =def. A generically dependent continuant that comes into existence through a social act and that, if it gets concretized, is concretized as a realizable entity.

Social Act =def. A process that is carried out by a conscious being or an aggregate of conscious beings, and is spontaneous, directed towards another conscious being or

another aggregate of conscious beings, and that needs to be perceived.

Obligor Role =def. A role that is either he specified output of an obligation generating social act or the concretization of a transferable obligation and that is realized by its bearer being the receiving part of a process that fulfills the previously agreed upon requirements.

Obligee Role =def. A role that is either the specified output of an obligation generating social act or the concretization of a transferable obligation and that is realized by its bearer being the providing part of a process that fulfills the previously agreed upon requirements.

Note, first, that the class *social act* includes as subclasses acts such as *deontic declarations*, which create, transfer, or eliminate SLGDCs or role, and *document acts* themselves, which includes any act of creating, transferring, or eliminating SLGDCs by means of documents. Note also that the connection between rights or obligations and agents is indirect. First an SLGDC is concretized in an obligor or obligee role, which is then borne by the agent. Lastly, note that this approach does not commit the same category mistake as the role view I discussed previously. In D-Acts, a person has the role of obligor, but this role is a concretization of a generically dependent continuant, which is transferrable.

In recent conversation, the authors of D-Acts have suggested that they may abandon SLGDCs, and take an agnostic position on the nature of deontic entities such as obligations. Instead, they would aim to track an agent's obligations indirectly by means of tracking agents' obligor and obligee roles. Whether this strategy is adequate for such tracking falls outside the scope of this paper. Let it suffice to say that there remains some interest in representing rights and obligations themselves and their relations to each other, to deontic powers, and to deontic acts.

The SLGDC approach is apparently based on Reinach's view that rights and obligations are “temporal objects of a special kind of which one has not yet taken notice,” i.e., that they are *sui generis*. Perhaps this view is correct that rights and obligations are radically unlike any other kind of entity. However, from a methodological perspective, it is advisable to treat rights and obligations as *sui generis* only if we have first exhausted all other possibilities. Thus, while this view is perhaps not untenable, it can be rejected if we discover an acceptable, more conservative ontological approach. The following section discusses such an approach.

3.4 Directive Information Entities

The final proposal draws its impetus from the observation that rights and obligations are action-guiding. Intuitively, an obligation specifies a type or course of action, namely, one which the obligor is in some sense required to perform.

Likewise, a right specifies a type or course of action which either the right-bearer may perform with impunity (in the case of negative rights) or which others must perform for her (in the case of positive rights).

Such specifications or prescriptions of action have been represented already within IAO under the category of *information content entity*:

Information Content Entity =def. A generically dependent continuant that is about some thing.

An information content entity is *concretized* by some particular set of qualities or realizable entities. For example, the content of *War and Peace* is concretized in the glyphs and spaces inside the physical book (Smith, *et al.*, 2013). The class *directive information entity* is then defined:

Directive Information Entity =def. An information content entity whose concretizations indicate to their bearer how to realize them in a process.

This definition is somewhat ambiguous insofar as it suggests that the concretizations of a directive information entity are responsible for indicating how the directive may be followed. This suggestion makes sense in the case of a recipe book whose qualities concretize a recipe, since the qualities of the recipe book do help indicate how to realize the recipe in the process of cooking. But IAO also speaks of the concretization of directive information in the dispositions of some agent, e.g., the disposition in a prospective chef to cook to follow the recipe. But it is hard to see in this case how the disposition is responsible for “indicating” anything to its bearer (the prospective chef).

Moreover, this definition suggests that the concretizations of a directive information entity always indicate to the bearers of those concretizations how the directive may be realized. But this also seems incorrect. For example, a recipe in a recipe book certainly bears qualities which concretize the recipe, but the bearer (the book) is not identical to the addressee of the directive (the prospective chef).

If we set aside these potential issues with the definition of *directive information entity*, the proposal is that *right* and *obligation* can be classified as subtypes of *directive information entity*. There are at least two arguments in favor of this proposal. The first stems from the parity between cases of rights and obligations on the one hand and of other directives on the other. To see how, consider the fact that directive information comes in several flavors. In some cases, a piece of directive information prescribes or specifies only an advisable means to achieving some goal. Recipes, maps, and assembly instructions do not pretend to mandate the adoption of the goals of making particular foods, traveling to particular destinations, or assembling particular pieces of furniture. Nor do they pretend to mandate the adoption of

the steps toward those goals. Rather, they merely prescribe an advisable way to achieve this goal. By contrast, some pieces of directive information present themselves to the addressee as mandating some behavior. The directive information concretized by a stop sign, for example, does not merely recommend stopping, but rather mandates (or presents itself as mandating) stopping. Likewise, an order from a superior to a subordinate within the context of an organizational hierarchy does not merely recommend, but mandates a course of action.

In this latter case, the directive information prescribes some course of action as required. If this prescription is appropriately authoritative (a point to which I will return in the following section), then simply in virtue of being the addressee of such directive information, that addressee is obligated to comply. In the case of the stop-sign, there is a (defeasible, *prima facie*) legal obligation; in the case of the order, there is a (defeasible, *prima facie*) professional or institutional obligation. What, then, is a right or obligation? Previously we identified them as kinds of constraint upon action. But this is precisely what at least one species of *directive information entity* does. Thus, even if not all directive information entities mandate the courses of action they prescribe or specify, *directive information entity* is nonetheless the appropriate superclass under which to situate *right* and *obligation*.

The second argument is based on the connection between deontic social acts and the emergence of rights and obligations. Consider, again, the case of a superior issuing an order to a subordinate. This issuing of the command is a manifestation of the superior’s authority over that subordinate—authority which is in large part constituted by the power to impose obligations upon his subordinates. But this scenario can also be described in the following terms: the superior is the agent of an act of commanding, which conveys directive information content to the subordinate, who is the addressee of that directive information. Here the superior’s authority—his power to put the subordinate under some obligation—is cashed out in terms of the ability to issue binding directives to the subordinate. Viewed from this angle, these appear to be two ways of describing the same thing: to put the subordinate under the obligation *just is* to make him the addressee of the binding directive because the obligation *just is* the directive information addressed to the subordinate. (Similar considerations might be brought to bear upon the case of promising, which can be described in terms of an agent’s issuing of a binding directive which has himself as the addressee.)

If entities such as *right* and *obligation* are species of *directive information entity*, and if the latter is the kind of entity that needs to be concretized, then one might wonder how *right* and *obligation* would be concretized on this proposal. The limitations of this present paper will allow only a few terse remarks on this subject. First, the concretization of

these directive information entities as rights and obligations must be kept distinct from their concretization in any qualities. For example, the directive information of a written order may be concretized in the qualities of a piece of paper, but it would be incorrect to describe the piece of paper as the bearer of the obligation. Second, they cannot be identified with the directive as concretized in an agent's dispositions. The reason is that this implies that an obligation remains concretized only so long as the obligor is disposed to fulfill it, but we can easily imagine someone having an obligation which they are not disposed to fulfill. Thus, the most promising suggestion, which appears in D-Acts, would be to hold that an obligation is a kind of binding specification for action which is concretized in an agent's social role. This would situate the concretization not in the dispositional properties of the agent, but in the agent's social context (e.g., her role as health-care professional).

4 CONCLUSION

The goal of this paper is to situate *right* and *obligation* within the correct parent class within the context of BFO. This leaves open the question of what the *differentiae* of *right* or *obligation* might be, i.e., what precisely would differentiate them from other directive information entities. Consequently, I have not endeavored to propose any full definition of *right* or *obligation*.

Previously I suggested that what differentiates some directives as binding is the fact that they are issued from an authoritative source. An ontological account of authority falls well outside the scope of this paper, since this would require addressing the substantial question of whether social rights and obligations are grounded in collectively accepted social conventions (Searle, 1969; 1995), or in the necessary relations holding between rights and obligations and the deontic acts which produce them (Reinach, 1919/1989), or in the disposition in one's wider society to punish those who fail to keep their obligations (Smith, 2016). Put otherwise, then, the basic proposal presented here concerns how to categorize entities like obligation relative to higher-level categories, not what ultimately grounds them.

That being said, if this proposal is correct, then the next task in the development of a BFO-based deontic ontology would be to address precisely this question. Future work would also aim to provide an analysis of the nature of *right* and its relationship to the intimately related notions of *permission*, *claim*, *immunity*, ontological characterizations of *deontic power* and *authority* (especially the place of authority in the hierarchy of social organizations) the nature and kinds of *deontic act*, and the actual development of an OWL-based, BFO-compliant deontic ontology for use in the biomedical domain and beyond.

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REFERENCES

- Almeida, M.B., Slaughter, L., Brochhausen, M. (2012) Towards an Ontology of Document Acts: Introducing a Document Act Template for Healthcare. In Herrero P., Panetto H., Meersman R., Dillon T. (eds.) *On the Move to Meaningful Internet Systems: OTM 2012 Workshops. Lecture Notes in Computer Science*, vol 7567. Springer, Berlin, Heidelberg.
- Arp, R., Smith, B., and Spear, A.D. (2015). *Building Ontologies with Basic Formal Ontology*. MIT Press, Cambridge MA.
- Brochhausen, M., Almeida, M.B., Slaughter, L. (2013). Towards a Formal Representation of Document Acts and the Resulting Legal Entities. *Johanssonian Investigations: Essays in Honour of Ingvar Johansson on His Seventieth Birthday*. Walter de Gruyter.
- Dumontier, M., Baker, C.J.O., Baran, J., Callahan, A., Chepelev, L., Cruz-Toledo, J., Del Rio, N.R., Duck, G., Furlong, L.I., Keath, N., Klassen, D., McCusker, J.P., Quera-Rosinach, N., Samwald, M., Villanueva-Rosales, N., Wilkinson, M.D., and Hoehndorf, R. (2014). The Semantic-science Integrated Ontology (SIO) for biomedical research and knowledge discovery, *J. Biomed. Semantics* 5(14). doi: 10.1186/2041-1480-5-14
- Lin, Y., Harris, M.R., Manion, F.J., Eisenhauer, E., Zhao, B., Shi, W., Karnovsky, A., and Yongqun, H. (2014). Development of a BFO-Based Informed Consent Ontology. Paper presented at the 5th International Conference on Biomedical Ontologies, Houston TX, USA.
- Lin, Y., Zheng, J., Yongqun, H. (2016). Ontology-based Representation and Analysis of Vaccination Informed Consent, *J. Biomed. Semantics* 7(20). doi: 10.1186/s13326-016-0062-4
- Reinach, A. (1919/1989). *The Apriori Foundations of Civil Law, Aletheia* 3, 1-142. Translated by John F. Crosby.
- Searle, J.R. (1969). *Speech Acts: An Essay in the Philosophy of Language*. Cambridge University Press, Cambridge.
- Searle, J.R. (1995). *The Construction of Social Reality*. The Free Press, New York.
- Smith, B. (1993). An Essay on Material Necessity. In Hanson, P. and Hunter, B. (eds.), *Return of the A Priori (Canad. J. Phil.)*, Suppl. Vol. 18, 301-322.
- Smith, B. (2012). How to Do Things with Documents. *Rivista di Estetica* 50, 179-198.
- Smith, B. (2014). Document Acts. In Ziv, A.K. and Schmid, H.B. (eds.), *Institutions, Emotions, and Group Agents: Contributions to Social Ontology*, 19-31. Springer, Dordrecht.
- Smith, B. (2016). Towards a BFO-Conformant Ontology of Deontic Entities, February 17, 2016 (Gainesville, FL), accessed July 13, 2017: <<http://ncor.buffalo.edu/2016/deontic-gainesville.pdf>>
- Smith, B. and Searle, J.R. (2003). The Construction of Social Reality: An Exchange, *Amer. J. Econ. and Sociol.* 62(2), 285-309.
- Smith, B., Malyuta, T., Rudnicki, R., Mandrick, W., Salmen, D., Morosoff, P., Duff D.K., Schoening, J., and Parent, K. (2013). IAO-Intel: An Ontology of Information Artifacts in the Intelligence Domain. Paper presented at the 8th International Conference on Semantic Technologies for Intelligence, Defense, and Security, Fairfax VA, USA.