Peirce's Classification of the Sciences†

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Abstract: Charles Peirce's classification of the sciences was designed shortly after the turn of the twentieth century. The classification has two main sources of inspiration: Comte's science classification and Kant's theoretical philosophy. Peirce's classification, like that of Comte, is hierarchically organised in that the more general and abstract sciences provide principles for the less general and more concrete sciences. However, Peirce includes and assigns a superordinate role to philosophical disciplines which analyse and provide logical, methodological and ontological principles for the specialised sciences, and which are based on everyday life experience. Moreover, Peirce recognises two main branches of specialised empirical science: the natural sciences, on the one hand, and the social sciences, the humanities and psychology on the other. While both branches share logical and methodological principles, they are based on different ontological principles in studying physical nature and the human mind and its products, respectively. Peirce's most basic philosophical discipline, phenomenology, transforms his early engagement with Kant. Peirce's classification of aesthetics, ethics and logic as normative sub-disciplines of philosophy relate to his philosophical pragmatism. Yet his more overarching division between theoretical (philosophical and specialised) sciences and practical sciences may be seen as problematic. Taking Peirce's historical account of scientific developments into consideration, however, I argue that his science classification and its emphasis on the interdependencies between the sciences could be seen as sustaining and supporting interdisciplinarity and interaction across fields of research, even across the divide between theoretical and practical sciences.

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1.0 Biographical and intellectual context and sources of inspiration

Charles S. Peirce (1839–1914)[1] was the founder of philosophical pragmatism and a pioneer in the development of formal logic.[2] He was educated both as a philosopher and as a natural scientist, and he was well-informed about developments in several disciplines. Both his philosophical pragmatism, which is concerned with the connections between knowledge and action,[3] and his familiarity with several fields of scientific research inform and guide his elaborate classification of the sciences from shortly after the turn of the twentieth century.[4] Notably, his pragmatism is reflected in his efforts to understand science as "a pursuit of living men" (CP 1.232) and a "living historic entity" (CP 1.44), rather than as "a mere abstract definition" (CP 1.232) or as "systematized knowledge on the shelves" (CP 1.234). One overall aim of his classification was thus to take account of actual developments in the natural sciences, but also in the social sciences, psychology and the humanities. Across fields of research, he saw processes of specialisation as a defining trait of modern science. In concrete sociological terms, he iden-

tified the results of these processes of specialisation by consulting "the list of scientific periodicals and the list of scientific societies" (CP 1.237). Besides his studies of scientific developments, however, his classification of the sciences had philosophical sources of inspiration. The two perhaps most imporant sources were Auguste Comte's influential classification of the sciences and Immanuel Kant's theoretical philosophy.

As Chiara Ambrosio has pointed out (2016), Peirce's classification of the sciences was inspired and influenced by several other science classifications developed during the nineteenth century, such as those of Jeremy Bentham ([1817] 1983) and William Whewell (1847). Yet it was the classification of the father of positivism, Auguste Comte (1855), which influenced Peirce the most. Peirce's classification shares with that of Comte that it reflects historical developments in both social and natural science. In fact, Peirce even notes particular developments in the humanities, such as his perception that "linguistics is becoming more and more nomological" (EP2, 39) or oriented toward discovering general laws. Yet, like Comte, Peirce is concerned with the unity of the sciences. From Comte's classification, Peirce takes the idea of an order of unilateral dependency between the sciences: the more general and abstract sciences provide principles for the more particular and concrete sciences.[5] In particular, Peirce, too, takes mathematics to be the most abstract science upon which other sciences depend. Nevertheless, Peirce's classification diverts from that of Comte in several ways. Peirce does not see mathematicians as making assertions about facts but rather takes them to develop hypotheses about purely imagined possibilities and to draw consequences from the hypotheses.[6] Moreover, among the specialised empirical sciences Peirce introduces a general division between the natural sciences, on the one hand, and the social sciences, psychology and the humanities, on the other. He thus recognizes variability and diversity between scientific subject matters and objects of knowledge to an extent not found in Comte's classification. More saliently, however, while metaphysics or philosophy generally is absent from Comte's classification, Peirce assigns to philosophy the status of the second most general science after mathematics. Drawing also on his own work in formal logic, he assigns a key role to philosophy as the provider of logical, methodological and ontological principles for all specialised empirical sciences.

The role of philosophy in Peirce's classification should be seen against the background of his Kantian legacy and as inspired by Kant's idea of the "architectonic" character of building philosophical systems in the *Critique of Pure Reason* (CP 1.176).[7] Already the early Peirce develops a classification of philosophical disciplines based on an epistemological analysis strongly influenced by Kant's first *Critique*. Later, in the 1890s, he reinvigorates and develops this classification in efforts to provide a philosophical and non-psychologistic basis for formal logic.[8] This classification serves as a starting point for his far more comprehensive science classification from around the turn of the century. Moreover, while the young Peirce endeavored to develop Kant's transcendental analysis of the categories of the understanding ("Verstand"),[9] his later work in mathematical logic leads him to derive categories formally from mathematics, and then to assign to philosophy the task of exploring and specifying the content of these categories through experience.[10] As I expand below, these categories, which the later Peirce names "firstness," "secondness" and "thirdness," inform several divisions of his comprehensive science classification. Yet, through his later category analysis, he modifies his early Kantian conception of philosophy. In his later view, philosophy considers experiential phenomena in an everyday life sense without using specialised methods or drawing on results from specialised scientific inquiries. In Peirce's own terms (EP2, 146), it "contents itself with observations such as come within the range of every man's normal experience, and for the most part in every waking hour of his life." In an era of incessant scientific specialisation, Peirce thus gives pride of place to phenomena of everyday life in philosophy, decades before Edmund Husserl turned phenomenology toward the pre-scientific life world (1970). In Peirce's classification, philosophy uncovers a shared experiential basis for all scientific specialisation and to which specialised researchers may need to take recourse in clarifying and reinterpreting scientific concepts and theories.[11]

With Peirce's sources of inspiration in mind, I now take a closer look, firstly, at the elements and formal architecture of his classification of the sciences. Secondly, I consider the categories lying at the heart of several of the divisions of the classification. Thirdly, I discuss the current relevance of the classification.

2.0 The structure and elements of Peirce's classification

In his classification, Peirce introduces a overarching tripartite division between three branches of science: 1) science of discovery, which includes the sciences mentioned above; 2) science of review, which encompasses any science classification, as well as history of science (EP2: 258–9, 458); and, 3) practical science or science "for the uses of life" (CP 1.239), for example, "pedagogics, ... vulgar arithmetic, horology, surveying, navigation, ... librarian's work" (CP 1.243).[12] Although Peirce's classification focuses mostly on sciences of the first branch, the fact that the two last branches are included may give pause to reflect on their significance for the classification as a whole.

Through including science of review, Peirce may be seen to reflexively recognize that a science classification is itself a

scientific activity of a certain kind. Yet, while a science classification is empirically constrained by its objects—historically evolving disciplines—its more general distinctions and divisions cannot be established simply by describing and labelling given scientific journals or societies. Since all classification, on Peirce's account, "is the arrangement of objects according to ideas" (CP 1.231), a science classification would need to develop general classificatory ideas by framing and testing conjectures, just like in any research process in the sciences of discovery.[13] This calls for further reflexivity and caution in conceptualising general divisions of the science classification, such as the division involving science of review itself and the other two branches of science. As for the need to develop classificatory ideas and to go beyond mere descriptions of existing scientific institutions, one could with Ambrosio further see Peirce's science classification as "a response to *external* constraints and pressures directly related to the social organization of the sciences in the nineteenth century" (2016, 4 emphasis original). Like several of the authors to which Peirce refers, such as Bentham and Comte, Peirce could thus be taken to respond to challenges related to the institutional organisation of the sciences, to a need for reform in higher education, as well as to more bureaucratic needs to survey and index all existing scientific publications in an era of incessant specialisation and internationalisation of science. For the internal divisions of Peirce's science classification, however, this suggests that there would be interactions or interconnections between sciences of review and practical sciences.

Peirce's division between science of discovery and practical science might also seem to be a bit too straight forward, given his more pragmatist qualifications of scientific activity. For example, in reflecting on the extensive social and practical consequences of modern science, Peirce recognises how science has transformed our everyday world "with its microscopes and telescopes, with its chemistry and electricity, and with its entirely new appliances of life, ... almost as much as if it had transported our race to another planet" (CP 5.513). Given that not only technological products and services, but also technological research infrastructures and scientific knowledge, started to leave laboratories and academic institutions in young industrial America, a division between pure and practical science becomes increasingly difficult to draw. Another consideration to the same effect comes from observing genealogical conditions of science. Peirce notes how sciences "have grown out of the useful arts" (CP 1.226). For example, he points out (EP2, 38-9) that "the steam engine made mechanical precision possible and needful" and that "[m]echanical precision rendered modern observational precision possible, and developed it." From this genealogical perspective, too, and given Peirce's commitment to account for science as a "living historic entity" (CP 1.44), a demarcation line between purely scientific and practical disciplines is not ready made and would need to be decided more carefully in each case.

As mentioned, the main thrust of Peirce's classification concerns further divisions within science of discovery. Again, the main division is tripartite: mathematics, philosophy and specialised empirical sciences.

While this tripartite division may not seem controversial, Peirce construes and conceptualises hierarchical relationships of dependence between the sciences, and he assigns distinct roles to mathematics and philosophy. Notably, Peirce's view that philosophy would need to draw on mathematics while mathematics needs no foundation in logic (which for Peirce is a philosophical discipline), contrasts sharply with the logicist views of Alfred North Whitehead and Bertrand Russell (1910-13) and the logicism of the Vienna Circle of logical positivism.[14] Moreover, the way in which Peirce assigns a certain foundational role to philosophy is peculiarly his own. Through its various sub-divisions, he points out, philosophy is to provide logical, methodological and ontological principles for specialised empirical disciplines. Yet, by drawing on everyday life experience, as well

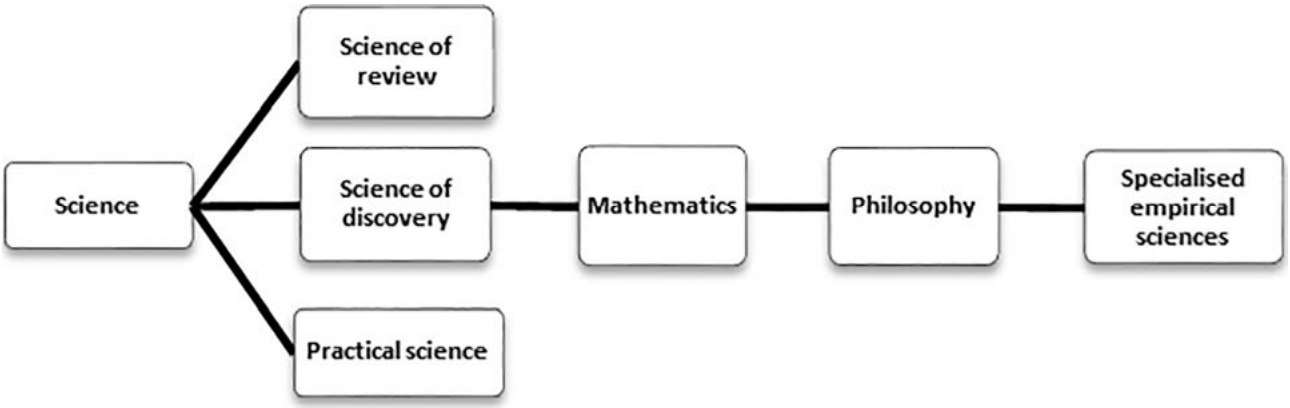

Figure 1. Peirce's classification of the sciences, 1903 (simplified hierarchical structure).

as on conceptual resources from mathematics, philosophy itself becomes an empirical and in principle fallible science. In fact, Peirce invents and calls his most basic philosophical discipline "phenomenology" (or "phaneroscopy"[15]), which is to explore the three categories that we consider more closely in the next section. Despite the name chosen, Peirce's idea of this discipline is not historically related to Edmund Husserl's phenomenology. Still, Peirce's stress on the need to develop a distinct philosophical and experiential inquiry, independent of specialised science and psychology in particular,[16] suggests parallels to Husserl.

Another novelty in Peirce's classification comes with the further sub-division of philosophy into normative science and metaphysics. Normative science consists of three philosophical disciplines that are hierarchically ordered: aesthetics, ethics and logic. This subdivision shows another pragmatist aspect of his classification. He makes logic, as the science of "self-controlled, or deliberate, thought," dependent on ethics, which concerns "self-controlled, or deliberate, conduct" (EP2, 160). Ethics, which distinguishes right from wrong, must in turn "appeal to esthetics for aid in determining the *summum bonum*" (EP2, 160) since aesthetics studies the very "admirableness of an ideal" (EP2, 142). In construing logical reasoning on the model of self-controlled moral conduct, Peirce takes the reasoner to be guided by an overarching ideal (the truth) and by general patterns or "norms" of right reasoning that are applicable in particular cases (CP 1.606). Despite his pragmatist construal of reasoning, however, he distinguishes the normative sciences generally as theoretical sciences and qualifies ethics in particular as a theoretical inquiry into "what the *fitness* of an ideal of conduct consists in" (CP 1.600 emphasis original). The normative sciences are thus distinguished from the practical sciences, which are not treated as "integrant parts" of the normative sciences as such (EP2, 198) but which are rather concerned with the conformity of action to a "given particular ideal" (CP 1.573). Nevertheless, the inclusion of the normative sciences in the overall classification still suggests that they could or even should be linked to the practical sciences. In fact, Peirce considers how practical sciences "may be probably expected to receive aid from [the Normative Sciences]" (EP2, 198), and he comments in particular that the exclusion of ethics from the practical sciences of "diplomacy and economics is immense folly" (CP 1.251). These suggested links to practical life might recall Comte's classification and positivism generally, which is closely connected to ideas of moral progress and social reform.[17] Yet, since such links come through philosophy, not sociology, as in Comte's classification, they would involve a more distanced and no direct commitment to social intervention. Notably, however, Peirce does propose a certain extended and critical application of his normative sciences to our inherited moral beliefs and their applicability to a modern technological society.[18]

In Peirce's classification, logic is not only conceived as a normative but as a semiotic science further divided into three sub-disciplines. "Speculative grammar" is "the general theory of the nature and meaning of signs" (EP2, 260); "logical critic" concerns the validity of arguments in the formal sense; and "methodeutic" or "speculative rhetoric" considers methodological principles for specialised scientific inquiries but also suggests principles for science communication and scientific writing.[19] Peirce's semiotic account of logic clearly differs from a purely formal approach in insisting on the requirement of studying the nature of signs in general, and the everyday use of linguistic signs in particular, prior to developing and using a formal logical system.[20]

As his last philosophical science, in addition to phenomenology and the normative sciences, Peirce introduces metaphysics. In its present condition, he admits, metaphysics is only "a puny, rickety, and scrofulous science" (EP2, 375). Yet, there is need, he thinks, for a general metaphysics which "seeks to give an account of the universe of mind and matter" (EP2, 259). Moreover, intimately linked to this philosophical science are two subordinated "nomological" sciences that specify ontological principles for two branches of specialised science of discovery: on the one hand, the natural sciences (or what Peirce generally calls "physical sciences"); on the other hand, the social sciences, humanities and psychology (or what he generally calls "psychical sciences").[21] Adopting an Aristotelian distinction, Peirce's nomological sciences distinguish "efficient causation" as the underlying principle of the natural sciences, and "final causation" as the principle of the social sciences, the humanities and psychology.[22] As for the classificaton of psychology in particular, we may note that Peirce was greatly impressed by the new experimental psychology of Gustav Fechner and Wilhelm Wundt, and that he even conducted pioneering research in this new field.[23] Nevertheless, he takes these new developments as mainly introducing new methods and not as redefining psychology as a natural science, or a science studying processes defined according to the principle of efficient causation.[24] Moreover, within each of the two branches of specialised science he further recognises two subordinated types of sciences that apply the principles formulated by the nomological sciences: classificatory and descriptive sciences. An example of a descriptive natural science is geology, while in the humanities history serves as an example of descriptive science.[25] Yet Peirce also suggests a more dynamic relation between the hiearchical levels. For example, while in the humanities and the social sciences he takes linguistics and anthropology to be classificatory sciences, he observes that "[l]inguistics is becoming more and more nomological [and] [a]nthropology is tending that same way" (EP2, 39).

The division between two branches of specialised science can be seen to bear a certain similarity to Wilhelm Dilthey's (1989) division between sciences based hermeneutically in

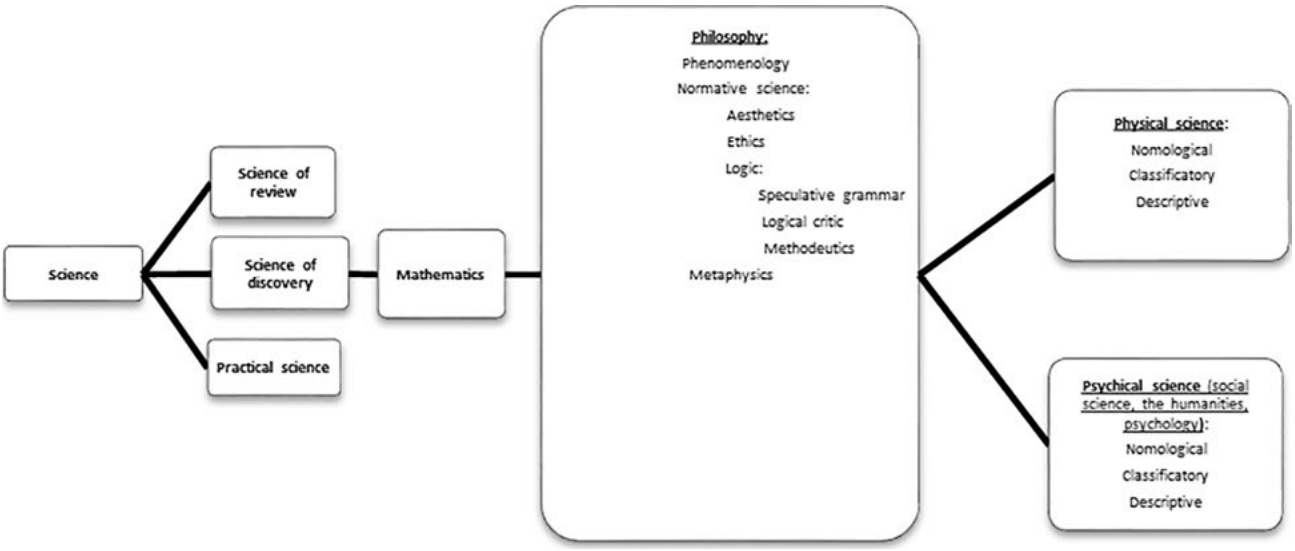

Figure 2. Peirce's classification of the sciences, 1903 (simplified presentation).

principles of understanding ("Verstehen") and sciences founded in principles of explaining according to general laws ("Erklären"). However, in so far as Peirce's philosophical sciences lay down logical and methodological principles for all specialised sciences, his classification still differs significantly from Dilthey's dualistic scheme. Moreover, his classification cuts across Dilthey's scheme in grouping humanities disciplines under nomological sciences, and his observation that "[li]nguistics is becoming more and more nomological" (EP2, 39) is to the same effect. In addition, his phenomenology and his speculative grammar uncover common experiential and semiotic ground between the two branches of specialised science. In so far, his philosophical approach may be seen to have more in common with Martin Heidegger's (2008) and Hans-Georg Gadamer's philosophical hermeneutics (2004) than with Dilthey's hermeneutics.

Despite the dual branching of the specialised empirical sciences, we have noted several triapartite divisions in his classification. These tripartite divisions suggest the need to consider his three categories more closely and the role of phenomenology in the overall classification.

3.0 Three universal categories: firstness, secondness and thirdness

Peirce's most basic philosophical science, phenomenology, analyses universal elements in human experience, and he introduces the categories "firstness," "secondness" and "thirdness" to describe and distinguish these elements. While Peirce's categories have an historical point of departure in the table of categories in Kant's first *Critique*,[26] he further evokes an Aristotelian-scholastic tradition by qualifying his categories as "modes of being" (CP 1.23). As modes of being, the categories would constitute the ways all phenomena in the world (including ourselves) are. Moreover, as for their foundational role for specialised empirical sciences and for metaphysics, the categories would be basic for any conceptualisation of what scientific theories are about. More indirectly, through defining what a "sign" is, and by informing Peirce's comprehensive classification of signs,[27] the categories are presupposed by any logical and scientific thinking, in so far as "all thinking is performed in Signs" (EP2, 447) or "is of the symbolic nature" (EP2, 307). Accordingly, his phenomenological analysis of the categories forms the backbone of his speculative grammar, which analyses the nature of signs and their meaning. Nevertheless, although Peirce's phenomenology draws on his mathematical logic of relations, his various outlines of a phenomenological analysis are rather sketchy and lack the methodological sophistication that we may find in his semiotic and logical writings. Let us first consider how he distinguishes his three categories.

Firstness, in its most general and primary sense, is "what is positively there," "regardless of what is absent," past and present (EP2, 150). Further, firstness is what is "sole and unique," involving no reference to, or comparison with any other phenomena (EP2, 150). As for its formal simplicity, the category is derived from monadic predicates in the mathematical logic of relations (as distinguished from dyadic and triadic predicates or relations).[28] Both from its formal and experiential sources, its content is fixed ahead of any specialised research into psychological correlates of the category, and it is prior to any distinctions introduced by other philosophical disciplines. Yet, as derived from ordinary experience, the phenomenological analysis provides further specifications of firstness in terms of experiential content. The category is thus

exemplified by "the quality of redness" as such, regardless of its "vidness and dimness," and taken as "not relative to anything" (EP2, 268). Firstness is further qualified through a "myriad-fold varieties" of sensory modalities: "an odor, say a smell of attar, or ... one infinite dead ache, [or] the hearing of [a] piercing eternal whistle" (EP2, 150). By emphatically appealing to pre-specialised experience, Peirce distinguishes such modes of presentation from what psychology would make an object of research.[29] On the other hand, like his two other categories, firstness informs the sign classification developed by speculative grammar.[30]

The category secondness is formally derived from the notion of dyadic relations in the mathematical logic of relations.[31] Abstaining from the latter's technical specifications, however, Peirce's second category captures a rudimentary idea of a pair of reacting singulars.[32] In Peirce's phenomenological analysis, secondness presupposes firstness, but cannot be reduced to firstness.[33] Peirce sometimes contrasts secondness to firstness by appealing to "the element of Struggle" or "a sense of resistance" experienced, for example, through "making a strong muscular effort, say that of pressing with all your might against a half-open door" (EP2, 150). Yet his phenomenological analysis is careful not to qualify secondness in terms of a physical or material domain as such. One reason for this may be found in the hierarchical order of the science classification. Being hierarchically prior to a metaphysics that sustains and justifies a division between natural and social science, the phenomenological account of secondness must abstain from using received ontological dichotomies to qualify this category; say, those of body/mind, physical/psychological, non-human/human, or effective/final causation. Peirce rather takes resort to more concrete characterisations, such as "a sense of resistance," but he also introduces more abstract distinctions, such as that between agent and patient.[34]

Like firstness, the second category, too, is used to define forms of signs analysed and classified by speculative grammar. In particular, secondness defines indexical signs and the indexicality of verbal discourse. The category enables separate and step-wise considerations of, for example, dyadic and dynamic relations involved by attention raising indices (such as tones of voice),[35] dyadic relations defining cognitive connections established between indices and indicated objects (pointing gestures)[36] and dyadic relations involved in furnishing verbally mediated information about an indicated object (propositional symbols).[37] Furthermore, secondness, as well as firstness, provides resources for considering non-cognitive and non-linguistic ways in which human agents are embodied in the world of experience, and for considering how such embodiment forms a basis for cognitive activity.

The analysis of thirdness concludes the categorical analysis, and the third category presupposes firstness and secondness but is reducible to neither of the two other categories.[38] From a formal point of view, Peirce's derivation of the category from a mathematical logic of relations is intrinsically connected to his argument for the irreducibility of triadic relations.[39] Since thirdness is "further away from common sense" (EP2, 158) a formal approach, therefore, becomes more salient for the analysis of this category. Nevertheless, for phenomenology it is crucial that claims concerning the universality and irreducibility of the categories can be supported by considerations from ordinary or pre-specialised experience. As for experiential specifications of thirdness, he sometimes considers examples of what he qualifies as "a *triadic* fact," such as that of a person giving something to someone and thus transferring ownership to the other person (EP2, 171 emphasis original). Such a fact, Peirce stresses, is constituted by a relation between all three elements involved and cannot be reduced to relations involving only two of them. However, Peirce's science classification leaves open further possibilities for experiential specifications. Since all philosophical disciplines are based on ordinary experience, thirdness could be more indirectly analysed and specified through other philosophical disciplines, such as speculative grammar or general metaphysics, or the more specific metaphysical inquiries into principles for natural and social science, respectively.

Firstly, the formal derivation of thirdness provides conceptual input for a definition of what a "sign" is that serves as a starting point for speculative grammar. Peirce explicates the very idea of a sign in terms of an irreducible triadic relation between three correlates: a representation (or "representamen"), the object represented, and the interpretation (or "interpretant") of the representation as representing the same object (CP 2.242). He sometimes defines thirdness simply as such a triadic relation.[40] His formal analysis of various types of triadic relations provides for a general classification of a variety of linguistic as well as non-linguistic signs, including the forms of indexicality briefly mentioned above.[41] Through this sign classification, the three categories gain significance for Peirce's classification of the sciences as a whole. The categories thus inform and enable considerations of signs essential to logic, such as different forms of proposition,[42] and signs on which specialised scientific observation and theorisation would depend, such as diagrams,[43] as well as types of scientific reasoning distinguished semiotically through different kinds of sign interpretants as abduction, induction and deduction.[44]

Peirce takes the categories, in particular thirdness, to sustain and enable conceptualisation and theoretisation in both natural and social science. In his hierarchical science classification, it is the task of metaphysics to apply the categories in exploring general features of reality to provide an ontological basis for theoretisation. As for the natural sciences, Peirce stresses that metaphysics would be concerned with the "reality of Thirdness" by qualifying the latter in

terms of the reality of laws or regularities in nature (EP2, 181). Assuming that "general principles are really operative in nature" (EP2, 183), his metaphysics thus advocates a version of scholastic realism. By using rather simple examples within the reach of ordinary experience, however, he asks what the reality of dispositional properties of inorganic things would consist in, such as the hardness of a diamond. This dispositional property, he argues, cannot be reduced to actual observable states of reacting singular phenomena,[45] which would be instances of secondness. Rather, he points out, the reality of dispositional properties proves itself through what would happen under certain conditions. A diamant's hardness thus consists in that the diamond would sustain the pressure of a knife-edge without being scratched, if the knife-edge were drawn over it.[46]

Peirce's explorations of thirdness further suggests the relevance of this category for social science research. More specifically, in considering the triadic sign-relation, he stresses how the triadic relation of the sign (or "representamen") to both an object and an interpretation ("interpretant") is irreducible. In particular, he qualifies this irreducible triadic relation as an "intellectual fact" (EP2, 171), and he states more elaborately that a "three-subject fact is comprehensible and is analogous to an utterance, a speech" (CP 6.323). In more specific terms, however, an interpretation of a verbal utterance is further defined and conditioned by shared norms and expectations. This is shown by Peirce's example of how acts of asserting and assenting to a proposition are made under a mutual understanding that telling a lie would be met with moral, and sometimes legal, sanctions.[47] Such instances may suggest how language use involves irreducible triadic relations to socially or institutionally conditioned interpretations (interpretants), as well as to objects. On the other hand, by neglecting such social and normative conditions, the analysis might tend to account for sign use in terms of dyadic relations defined, for example, by an utterance and some psychological intention behind the former, or, alternatively, by a semantic relation between utterance's verbal meaning and its reference. An even more convincing case for the irreducibility of thirdness is provided by Peirce's example of two persons making a contract.[48] Such institutionally bounded language use cannot be meaningfully analysed only in terms of sets of dyadic relations between reacting singular phenomena specified as, say, a signer and a document, between the two parties to a contract, or between the signed document and successive acts of the signers. Rather, a triadic relation would define the institutionally conditioned intent of the contract (interpretant), the contract (sign) and the state of affairs in the world the contract is about and is to regulate (object). As with an informal act of assertion, the signing of a contract is binding on language users and has practical consequences if the norms at stake are broken. In the case of contracts, however, such norms are expressively given through the contract's intent "that certain conditional rules shall govern the conduct of [the contractors]" (CP 1.475). To use a speech act theoretical distinction, in either case, language use should be analysed in terms of "illocutionary effects," rather than merely as "perlocutionary effects."[49] Like Peirce's interpretant illocutionary effects can only be accounted for by triadic relations,[50] while perlocutionary effects may be analysed as dyadic relations between linguistic acts and certain physical, physiological or psychological reactions to those acts. Given these specifications, Peirce's point about the irreducibility of triadic relations and thirdness gains relevance for recent developments in the social sciences, such as Jürgen Habermas' (1984-7) theory of communicative action.

By considering how thirdness defines ontological principles in social and natural science and how Peirce's three categories inform his sign classification, we have noted how the categories gain significance for his science classification as a whole. Yet, Peirce further suggests that his categories can be applied directly to the divisions between the sciences in qualifying both their distinctness and their hierarchical dependence relations. In distinguishing the three main philosophical sciences, he qualifies them briefly in terms of firstness, secondness and thirdness, respectively. As for phenomenology, he uses the category of firstness in a certain metascientific sense in pointing out that this science treats of phenomena "in their immediate phenomenal character, in themselves as phenomena ... [and] ... thus ... in their Firstness" (EP2, 197). Moreover, in attempting to qualify both the distinctness of the normative sciences and their dependence on phenomenlogy, he uses the category of secondness in a rather abstract and highly generalised sense. The normative sciences, he claims, concern "the conformity of phenomena *to ends* which are not immanent within those phenomena" (EP2, 199 emphasis original), and in so far, they treat "of Phenomena in their Secondness" (EP2, 197). While admitting that this qualification might be "too narrow" (EP2, 197), his further qualification of metaphysics is in line with our consideration above of its relevance for the specialised sciences (EP2, 197): "Metaphysics ... treats of Phenomena in their Thirdness." Nevertheless, his use of firstness and secondness in accounting for phenomenology, normative science and metaphysics, as well as for metaphysics' dependence on the two former sciences, may seem little convincing compared to his more elaborate attempt to ground both metaphysics and the specialised sciences in a sign classification and logical and methodological principles provided by speculative grammar, logical critic and methodeutic, respectively.

However, the categories may also be seen to bear on the subdivisions within each branch of specialised science. As mentioned above, Peirce classifies both natural and the social sciences hierarchically into nomological, classificatory

and descriptive sciences.[51] Thirdness informs and sustains the nomological sciences through laws or ontological principles for the various fields of natural and social science research, while these laws and principles are in turn to provide the basis for classification in the classificatory sciences and for possible explanation of phenomena described by descriptive sciences. Yet, through this hierarchical order of classification, Peirce deliberatively idealises actual scientific developments and tendencies toward theorising laws and regularities. In fact, the hierarchical order "reverses" the historical order of development in so far as there is "a well-marked tendency for a science to be first descriptive, later classificatory, and lastly to embrace all classes in one law" (CP 1.226). Moreover, Peirce's historical exemplifications provide opportunity to reflect on the distinctness, as well as the historical priority of "classificatory" and "descriptive sciences" in categorical terms and in terms of secondness and firstness in particular.

Distinguishing classificatory sciences more carefully, Peirce uses chemistry as an example, a science he knows from training. Peirce admits that, in its actual state of development, chemistry is little concerned with general physical or physio-chemical laws but is "limited to the study of reactions, to the structure of compounds, and to the behavior of elements in combination" (CP 1.260). Rather than inquiring deeper into the properties of the different substances, a chemist seeks "to identify them and to make out their constitutional relations" (CP 1.260). Hence, in emphasizing concrete reactions and behaviors in identifying elements in combinations, Peirce's account suggests that secondness is an underlying category in the chemist's conceptual and classificatory scheme. Secondness is further the defining category in Peirce's semiotic account of a chemist's procedures for identifying a particular element, using lithium as an example. A chemist identifies this element by using an operational definition or a "precept" that "tells you what to *do* in order to gain a perceptual acquaintance with the object of the word" (CP 2.330). Since this definition instructs the scientist how (s)he is to interact with and manipulate substances in order to identify the element, it works basically like an indexical, which Peirce defines in terms of secondness. Hence, using chemistry as a case, Peirce's distinguishes what classificatory sciences are by giving priority to secondness rather than thirdness.

In Peirce's hierarchical and Comte-inspired classification, descriptive sciences, such as geology and astronomy (CP 1.198), are subordinated to nomological and classificatory sciences. While "going into the utmost detail, describing individual phenomena" (EP2, 258), these sciences would endeavor "to explain their phenomena by the principles of nomological and classificatory physics" (EP2, 259). This hiearchical relationship, however, takes little account of how observational activities distinguish these sciences and specialised sciences generally. As Peirce stresses time and again, observational activities not only provide an empirical basis for confirmation or refutation of explanatory theories but is a main driver for scientific and theoretical development, and hence for scientific specialisation. What distinguishes specialised sciences as such, he points out, is "a peculiar form of observation" (CP 1.99). Historically, new technologies of observation have enabled researchers to discover and take account of ever more fine-grained or complex aspects of micro or macro level phenomena. "The great landmarks in the history of science," he notes, "are to be placed at the points of where new instruments, or other means of observation, are introduced" (CP 1.102). One may thus distinguish "[a]stronomy before the telescope and astronomy after the telescope. Prephotographic astronomy and photographic astronomy. Chemistry before the exact analytic balance, and after" (CP 1.102). While the phenomenal qualities mediated by sophisticated optical technologies are different from those studied by phenomenology through everyday life experience, they would still be phenomenal qualities, or, when qualified by Peirce's semiotic distinctions, "qualisigns" or "icons" (CP 2.254). In so far, they may be defined in terms of firstness. In fact, optical instruments may be specifically designed to capture certain phenomenal qualities while ignoring others, as seen, for example, in that "the qualities striven for in a telescopic objective are of no consequence in a microscopical objective" (EP2, 131). Moreover, due to particular technologies of observation and particular training, a member of a certain scientific community, say, "a bacteriologist," "will live in quite a different world - quite a different aggregate of experience," than a layperson, but also than a member of a different scientific communty, and "neither has seen the world in which the other lives" (EP2, 131). Hence, in qualifying specialised sciences in terms of what the Husserlean phenomenologist would term "life worlds,"[52] Peirce suggests that firstness, not only secondness and thirdness, may distinguish specialised sciences as such.

4.0 The relevance of Peirce's classification

Like Comte, Peirce stresses the unity and interdependence of the sciences, as well as their diversifications and their distinctness. While we have seen how Peirce's categories of firstness and secondness may qualify the distinctness of the various specialised sciences, his category of thirdness, through his "nomological sciences," would stress tendencies across the specialised sciences to search for general laws and regularities. In particular, we noted that his division between the natural sciences and the social or human sciences in effect resists Dilthey's dualistic scheme in taking account of the fact that parts of the humanities, too, are searching for laws or law-like regularities, as in the case of linguistics.

In this regard, Peirce's classification gains relevance in the light of Rens Bod's (2013) recent comprehensive effort to rewrite the history of the humanities.[53] Contesting the Diltheyan understanding-explanation dichotomy, as well as Wilhelm Windelband's distinction between nomothetic and idiographic approaches to knowledge, Bod's study of historical developments across the humanities shows (2013, 7) how "the search for patterns and principles in the humanities is a continuous tradition." While Peirce's classification provides sweeping evidence against Dilthey's and Windelband's schemes from the late nineteenth century, Bod's project provides a comprehensive historical account from antiquity up to the present that challenges and undermines these schemes.

As noted above, Peirce's hierarchical classification most strikingly distinguishes itself from that of Comte by including and assigning distinct roles to philosophical disciplines. Peirce's classification thus stresses the unity and interdependencies of the sciences through principles articulated and analysed by phenomenology, the normative sciences and metaphysics. Given Peirce's elaboration of his normative sciences more specifically, we may highlight the relevance of this branch of philosophy in particular.

Although Peirce fails to suggest ethical guidelines for the conduct of research in the contemporary sense, he does assign a superordinate role to ethics in relation to all specialised empirical sciences. More specifically, in his science classification, ethics informs principles of "self-controlled" logical reasoning and also, more indirectly, the methodological application of logical reasoning in specialised empirical research. More importanly, however, in so far as ethics studies principles of right conduct in general and "what the fitness of an ideal of conduct consists in" (CP 1.600), Peirce's science classification would sustain and support a further exploration and specification of ethical norms for the conduct of research. Notably, his later proposal to extend the role of the normative sciences to critically reflect on our inherited moral beliefs and their applicability to "the new world created by science" (CP 5.513) seems even more relevant now than in Peirce's days. In particular, since the objective of this critical reflection would be to reconsolidate moral beliefs that "remain indubitable" (CP 5.513), Peirce's proposal is relevant for ongoing discussions of how our inherited moral ideals of human dignity and worth bear on current medical and genetic research, notably stem cell research.

Furthermore, Peirce's semiotic account of logic may be seen to have not only theoretical but educational relevance. Noting that his three semiotic disciplines speculative grammar, logical critic and methodeutics is modelled on the medieval trivium (grammar, logic and rhetoric) (EP2, 327), his semiotic account of logic may be seen to support university curricula that aspire to establish a common frame of reference for its various specialised studies through general courses in logic, methodology and scientific writing.[54] The stress on the interdependence of the sciences in Peirce's classification gains further relevance when taken together with his pragmatist view of science as "a pursuit of living men" (CP 1.232) and as a "living historic entity" (CP 1.44). As Jaime Nubiola (2005) has pointed out, in several of his historical reflections, Peirce considers cross- and interdisciplinarity as a condition for scientific development. The hiearchical relationships between nomological, classificatory and descriptive sciences in his classification may thus translate more dynamically into influences, loans and interactions between sciences. For example, Peirce thinks that those who study "different kinds of plants and animals cannot attain any true understanding of taxonomic biology until they can be guided by the discoveries of the physiologists" (CP 1.226). In turn, "the physiologist may be aided" by facts collected by taxonomic biologists (CP 1.226). Moreover, significant scientific developments have been achieved through interaction between the various disciplines and fields of research: "Darwin adapted to biology the methods of Malthus and the economists; Maxwell adapted to ... electricity the methods of hydrodynamics ... Wundt adapts to psychology the methods of physiology; ... Cournot adapted to political economy the calculus of variations" (EP1, 212). Extrapolating from these historical cases, Peirce ponders that, in the future, major advances will come from cross-disciplinary uptakes through which one succeeds "in adapting the methods of one science to the investigation of another" (EP1, 212). In line with this hypothesised trajectory, we may briefly note how comprehensive research fields have emerged through cross- or interdisciplinary uptake in the twentieth century, such as biochemistry, cellular biology and ecology in the natural sciences; neuropsychology, evolutionary psychology and social psychology in psychology; and socio-linguistics, gender studies, digital and environmental humanities in the social science and the humanities. In particular, Peirce could be seen to anticipate the emergence of the interdisciplinary field of science and technology studies (STS) in stipulating "ethnology of technology" (EP2, 261) as part of ethnology. Yet some such developments would challenge his dual branching of the specialised sciences, in particular developments involving not only uptake of methods but theories from other disciplines. Obvious examples would be evolutionary psychology and neuropsychology, which would have to be taken as natural science disciplines in Peirce's classification, rather than as psychological disciplines proper.

At times Peirce stresses a kind of interdisciplinary interaction that in effect bridges an overarching division in his classification: the division between science of discovery and practical science. Interaction across this divide may evolve, he suggests, from issues or problems in the practical sciences and thus from some "dynamical relations" or "a compulsive

quality of action" (CP 7.52). Action coordination and cooperation arise in so far as "one group may stimulate another by demanding the solution of some problem" (CP 7.52). Yet the interdisciplinary nature of such cooperation would not consist simply in applications or practical adaptations of existing theories or methods in the specialised sciences. Peirce rather suggests that new theories and concepts need to be developed in response to a major practical or social problem, using as one of his examples Pasteur's discoveries of the nature of bacteria "with their far-reaching blessings to the human species" (7.52). "In this way," he maintains, "the practical sciences incessantly egg on researches into theory" (CP 7.52). The kind of theory and knowledge development considered can thus be seen to bear similarity to what Gibbons, Limoges, Nowotny et al (1994) and Nowotny, Scott and Gibbons (2001) more recently have qualified as the production of "Mode 2" knowledge: knowledge that is transdisciplinary, rather than disciplinary, socially distributed across various sectors of society and developed in contexts of application and use. However, recalling his general problematisation of the extensive social implementation of science and technology and the ensuing doubts concerning our inherited moral beliefs (CP 5.513), Peirce could be seen to call for interdisciplinary involvement also on part of the more general sciences of discovery, the normative disciplines ethics, esthetics and logic in particular. In so far as scientific discoveries lead to technological interventions in industry, transportation or medicine that challenge basic moral beliefs, say, concerning human dignity and welfare or environmental protection and animal welfare, Peirce's proposal would invite ethical, esthetic and semiotic inquiries into the meaning and applicability of our shared moral beliefs. Following Peirce's proposal, such interdisciplinary engagement may further enhance moral reflection in practitioners of relevant practical sciences and forge a sense of moral and social responsibility in specialised empirical researchers involved. Hence, again the divisons and hiearchical dependencies in Peirce's classification may be conceived as ports of entry for interaction and cooperation across the sciences.

Notes

1. References to Peirce's works are to: 1) *Collected Papers of Charles Sanders Peirce* (Peirce 1931–58) with the abbreviation "CP" and where the number to the left of the decimal point indicates the volume and the number to the right the paragraph; 2) *The Essential Peirce* (Peirce 1992-8) with the abbreviation "EP," and where references are to the volume and page number; 3) Unpublished manuscripts in microfilm version that are indicated with "MS.," and the numbers refer to those in Robin 1967.
2. See Dipert 2004.
3. The historical point of departure of philosophical pragmatism in America is Peirce's two texts "The fixation of belief" (EP1, 109-23), originally published in 1877, and "How to make our Ideas clear" (EP1, 124-41), published in 1878.
4. In this article, I draw both on Peirce's classification of the sciences from 1902 (which is found in "A Detailed Classification of the Sciences" from "Minute Logic" [CP 1.203-83]) and his classification from 1903 ("An outline classification of the sciences" [EP2, 258-66]). In so far as there are discrepancies between the two classifications, I follow the latter. For a developmental account of the two classifications, see Atkins (2006).
5. See EP2, 35, EP2, 258.
6. See CP 1.184, EP2, 144, 146.
7. See Murphey (1961, 1-3).
8. See Midtgarden (2001, 2007).
9. See his "On a new list of categories" (EP1, 1-10).
10. See Atkins (2006, 487-8).
11. See CP 1.246, 1.249, 1.278.
12. Peirce's classification of practical science is elaborated in MS 1343.
13. See CP 1.234.
14. See also de Waal (2005).
15. See "The Basis of Pragmaticism in Phaneroscopy" (EP2, 360-70).
16. See CP 1.241, EP2, 147-8.
17. See Schmaus, Pickering, Bourdeau (2018).
18. See CP 5.513 and Midtgarden (2014).
19. See EP2, 326-30.
20. See also Midtgarden (2001).
21. See EP2, 39, EP2: 260.
22. See EP2, 250, 264.
23. See Peirce's and Joseph Jastrow's "On small differences of sensation" (1885) (reprinted in CP 7.21-35). For a thorough discussion of Peirce's contribution to psychology, see Cadwallader (1975).
24. See in particular EP2, 470-1. Peirce's position may thus be seen as reflecting that of Wundt himself and in effect as being opposed to the efforts of the younger German psychologists Oswald Külpbe, Hermann Ebbinghaus and E.B. Titchener of construing psychology as a natural science. For a useful discussion of these latter efforts, see Danziger (1979).
25. See EP2, 36-7.
26. See EP2, 148, CP 1.563.
27. See his "Nomenclature and Divisions of Triadic Relations, as far as they are determined" (EP2, 289-99).
28. See EP2, 427-8.
29. Sometimes he seeks to avoid the term "feeling" and rather defines firstness through "sense of quality," which would, for example, be "the sort of element that makes

red to be such as it is, whatever anything else may be" (CP 8.267).

30. In one of Peirce's most systematic classification of signs, he uses firstness (although not the word "firstness" in this context but rather "first" and "possibility") in a technical and step-wise manner to define the syntax of a propositional symbol, a so-called "dicent symbol" (EP2, 295-6). Such a symbol requires through its interpretation (or "interpretant") an "iconic legisign," where the latter has already been exemplified by "a diagram, a part from its factual individuality" (EP2, 294), and "icon" has been defined by firstness (EP2, 291) and "legisign" by thirdness (EP2, 291). Yet, even firstness has here initially been defined as an element of triadic relations (EP2, 289-90).
31. For Peirce's algebraic treatments of dyadic relatives, see for instance CP 3.492-8.
32. See EP2, 160-1.
33. CP 1.530, EP2, 270.
34. EP2, 150.
35. In Peirce's terminology, this would be a "rhematic indexical sinsign" (EP2, 294).
36. This would be what Peirce calls a "dicent sinsign" (EP2, 294).
37. This would be a "dicent symbol" (EP2, 295).
38. CP 1.530, EP2, 240.
39. For a discussion of Peirce's argument, see Hookway 1985: 97-101.
40. See CP 1.541.
41. See Peirce's ten-fold classifications of signs, EP2, 289-99.
42. See EP2, 299.
43. EP2, 294, 298.
44. EP2, 297-9.
45. See EP2, 396, 401-2.
46. See EP2, 354, 356-7.
47. See EP2, 278, 311-12, CP 5.546.
48. CP 1.475.
49. See Austin (1962, 101ff).
50. In agreement with Peirce's triadic sign-relation, an illocutionary act would involve a socially (or institutionally) conditioned uptake (interpretant), an uttered propositional symbol or "locutionary act" (sign), the propositional content of which would be about something in the world (object). As for the latter, however, an illocutionary act would involve either a "world-to-word," or a "word-to-world direction of fit" (see Searle 1979, 11-20).
51. EP2, 259-62.
52. Note how Husserl sometimes qualifies his concept of the life world in terms of "the world in which [the physicist] sees his measuring instuments, hears time-beats, estimates visible magnitudes, etc. - the world in which, furthermore, he knows himself to be included with all his activities and all his theoretical ideas" (1970, 121).
53. I thank Rasmus Slaattelid for drawing my attention to Bod's research.
54. A case in point is the introductory course Examen Philosophicum at Norwegian Universities. This course is mandatory for all curricula and exams at, for example, the University of Oslo (see Lovdata 2006).

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