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Frege's Antipsychologicism: Some Clarifications[1]

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ABSTRACT: The paper aims at a clarification of Frege's antipsychologism. It analyses Frege's putting into opposition of logic/mathematics and psychology. It then investigates the historical roots of Frege's views in Kant's *Critique of Pure Reason* and in J. Müller's and H. von Helmholtz's physiological psychology. It explicates also how the opposition between Frege's (third) realm of thoughts and that of representations is rooted in the opposition of a transcendentally understood subject (consciousness) and a naturalistic understanding of an empirical subject (consciousness), as well as its implications in the philosophy of logical positivism/empiricism. Finally, by drawing on Habermas' linguistico-pragmatically grounded understanding of the lifeworld it shows how that opposition can be overcome and how to understand Frege's realm of thoughts.

KEYWORDS: Antipsychologism – Frege – H. von Helmholtz – J. Habermas – J. Müller – Kant – lifeworld – logic – physiological psychology.

1. Introduction

The aim of this paper is to offer an analysis of Frege's putting into opposition logic and mathematics, on the one hand, and psychology, on the other; an opposition succinctly expressed by the term "antipsychologism".

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Unlike the more recent approaches,[2] I approach Frege's antipsychologism by relating Frege's views to the physiological psychology of J. Müller and H. von Helmholtz and show some of its consequences outside the framework of logic and logical foundations of mathematics in which Frege's *oeuvre* moved, namely, in the logico-positivistically inspired philosophy of science and philosophy of social sciences.

I start with Frege's putting into opposition of logic/mathematics and psychology as well as his understanding of the terms "knowledge" and "representations". Then, I show how the opposition between Frege's (third) realm of thoughts and that of representations is rooted in the opposition of a transcendentally understood subject (consciousness) and a naturalistic understanding of an empirical subject (consciousness), as well as its implications in the philosophy of logical positivism/empiricism. Finally, by drawing on Habermas' linguistico-pragmatically grounded understanding of the lifeworld I show how that opposition can be overcome and how to understand Frege's realm of thoughts.

2. Frege on knowledge vs. representation

Frege puts into opposition logic/mathematics and psychology in the *Grundlagen der Arithmetik*, where he declares that the proper feature of mathematics is "the refusal of all assistance from the direction of psychology" and he states as a maxim: "always to separate the psychological from the logical, the subjective from the objective" (Frege 1884, xi-x).

Already in this work he assigns to representations (*Vorstellungen*), when compared to logic/mathematics, a special status. He declares: "If number were a representation, then arithmetic would be psychology. But the former is no more psychology then, say, astronomy" (Frege 1884, § 27, 37).[3] In a footnote he, then, adds: "The representation in the subjective sense is that to what psychological laws of association are related; it is of a sensual, pictorial character. The subjective representation is demonstrably different in different human beings" (Frege 1884, § 27, 37).

In the 1890s Frege makes more precise his characterization of representations by opposing them to the sense (*Sinn*) of language expressions. He

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2 On these see, e.g., Picardi (1996); an exemption here is McCarty (2000).

3 In this paper, all quotes from Frege's texts are my translations from German.

introduces the logical entity, Sense, in the article *On Sense and Reference* via well-known examples, one of which is taken from astronomical knowledge expressed by means of the statement "Morning Star is the Evening Star" and the other taken from geometrical knowledge about the intersection of lines *a*, *b*, *c* – connecting the vertices in a triangle with the midpoints of the opposite sites of the triangle – in one point, so that it holds that the intersection of *a* and *b* is the intersection of *b* and *c*. From the point of view of our paper it is worth noting that Frege not only draws on the knowledge produced by particular sciences (astronomy and geometry), but also that he argues in favor of the introduction of the term "sense" by means of an *epistemological* argument. For him, both examples stand for a *synthetic* type of knowledge, which, as Frege (1967b, 143) declares, contains a "very valuable extension of our cognition [*Erkenntnis*]".

A similar epistemological argument can be found in his introduction of the term "thought" (*Gedanke*) which he characterizes as the thinking's "objective content which is capable of being the common property of many" (Frege 1967b, 148), and where "many" need not stand only for a particular group of humans coexisting in time, but may also stand for humanity as such, which "has a common store [*Schatz*] of thoughts and which is transmitted from one generation to another" (Frege 1967b, 146).

These epistemological reflections by Frege take a turn once he integrates them into what can be labeled as the "three-world-model," and whose points of departure had already been delineated in *Sense and Reference* and fully developed in the article *Thought*. In the former, Frege opposes the entities *sense* and *reference* (*Bedeutung*) to representations understood as an "internal image" (cf. Frege 1967b, 145), and which are created by memories of sensory impressions of an individual and of activities (both internal and external) performed by him/her. Therefore, he claims, representations vary between individuals and in the same individual, so that the same intersubjectively shared sense is with respect to particular individuals always related to highly idiosyncratic and varying representations. So:

> The representation is subjective: one man's representation is not that of another. There results, as a matter of course, a variety of differences in the representations associated with the same sense ... The representation thus differs essentially from a sign's sense, which may be the common property of many people, and so is not a part or a mode of the individual soul (*Einzelseele*) ... In the light of this, one need have no scruples in speaking simply of sense as such, whereas in the case of the

> representation one must, strictly speaking, add to whom it belongs and at what time ... If two persons imagine (*vorstellen*) the same, each still has his own representation ... The representation which we ... have ... is completely subjective. (Frege 1967b, 146)

Let us now turn to Frege's approach to the category *representation*, which he characterizes as follows (1967c, 351-352):

1. Representations cannot be perceived.
2. Representations are something which is had/owned; a particular individual's representations belong to the content of his/her consciousness. To be the content of his/her consciousness belongs to the nature of his/her representation.
3. Representations need an owner/carrier.
4. Each representation has only one owner/carrier.

From these characterizations Frege draws the important conclusion that *no individual can compare his/her own representations with those which belong to other individuals* (cf. Frege 1967c, 351-352). And, based on these reflections, Frege views the process of human thinking (i.e., grasping the thoughts from the third realm) as tight to the performances of an *individual's thinking*. And, he views it as a term belonging to *psychology as science*; "We say 'I imagine something' and mean by this an inner process, while by 'representation' we understand an inner mental picture... representations: these may be reserved for psychology" (cf. Frege 1967a, 123).

3. Some clarifications

There are two questions worth posing here. Where does Frege's distinction between representation and knowledge originate? And what type of psychology does Frege have in mind when making that distinction? The first question can be answered in the context of Kant's *Critique of Pure Reason* (CPR), the second with respect to the psychology of the last quarter of 19th century, on which Frege drew.

3.1. The historical roots 1 – Kant

The fact that Frege in his reflections on the term "representation" drew terminologically from Kant's philosophy can be seen in a footnote from the

Grundlagen, where he differentiates between a representation in an objective and in a subjective sense, and then declares:

> Because Kant associated with this word both meanings, he gave to his tenet a very subjective, idealistic coloring ... The distinction here made is as justified as that between psychology and logic. (Frege 1884, § 27, 37)

Kant presents in the CPR a hierarchical view of cognitive capabilities spanning sensibility, understanding and reason. He views sensations, intuitions, representations and understanding as the most closely interrelated. He presupposes the existence of "two stems of human cognition ... namely sensibility and understanding, through the first of which objects are given to us, but through the second of which they are thought" (Kant 1998, A15=B29, 135). He offers a precise description of these stems as follows:

> Our cognition arises from two fundamental sources in the mind, the first of which is the reception of representations (the receptivity of impressions), the second the faculty for cognizing an object by means of these representations (spontaneity of concepts); through the former an object is *given* to us, through the latter it is *thought* in relation to that representation (as a mere determination of the mind). Intuition and concepts therefore constitute the elements of all our cognition, so that neither concepts without intuition corresponding to them in some way nor intuition without concepts can yield a cognition. (Kant 1998, A50=B74, 193)

For these representations it holds that "as determinations of the mind [they] themselves belong to the inner state" (Kant 1998, A34=B60, 163).

With respect to Frege's extrusion of (subjective) representations from the realm investigated by logic/mathematics and their subsumption under a realm being investigated by psychology, it is worth to state here Kant's division of what he labels as the *Science of Logic* (*Wissenschaftslogik*) (Kant 1998, A52=B76, 194) into a *general logic* (*Logik des allgemeinen Verstandsgebrauchs*) and *special logic* (*Logik des besonderen Verstandsgebrauchs*). The first can perform its work without any special knowledge of objects. It divides further into *pure general (formal) logic* and into *applied general logic*. The former investigates the "absolutely necessary rules of thinking" (Kant 1998, A52=B76, 194), which thinking has to follow in order to be correct. It serves as the canon of judging (Kant 1998, A61=B85, 198) and as such "draws nothing from psychology ... which therefore has no influence at all

on the canon of the understanding" (Kant 1998, A54=B78, 195). It does not investigate the thinking which has the status of cognition (*Erkennen*), i.e., when there exists or can exist an object related to thinking; it has just "the modest merit of guarding against error" (Kant 1998, A795=B823, 672), so that thinking can be free of contradictions (Kant 1998, Bxxvi-xxvii, 115-116).

The applied general logic takes into account the accidental conditions under which the rules of formal logic are employed by humans, like the force of habit, inclination, prejudice, etc. It has, according to Kant, the character of a *psychology* of thinking (Kant 1998, A54-5=78-9, 195).[4]

Kant's "special type of logic" is in fact a set of logics because it depends on the way the proofs and arguments are performed in each respective special science. What all these logics still have in common is that they fulfill, in relation to the respective special science, the task of an organon (instrument of cognition); their purpose is the "expansion and extension of its knowledge (*Kenntnis*)" (Kant 1998, A61=B86, 199). What the CPR then pursues is an investigation into the suppositions for the creation of logic of just one science, namely, of metaphysics, and as such is based on its division into transcendental aesthetic and transcendental logic.

Given this division of the science of logic on Kant's part, it can readily be seen that in the CPR the empirical subject is banished from investigation by the logic of metaphysics and relegated into the realm subjected to investigation by psychology. The subject, or to be more precise, its consciousness, which should be dealt with by the logic of metaphysics is an anonymous consciousness of a transcendental "I", which he views as enabling the unity of all experience (Kant 1998, A107, 232).

We can now delineate the differences and similarities between Kant and Frege. First, while Kant employs the term "representation" both in transcendental aesthetic and transcendental logic, that is, in epistemology, Frege shifts it to psychology and assigns to it, in comparison to Kant, another meaning. Second, both Kant (in his CPR) and Frege rely on a transcendental entity: the CPR on a transcendental *I*, Frege on the realm of thought completely detached from empirical *I*'s. And, third, both Kant's

[4] For a more recent analysis of Kant's approach to psychology see Schmidt (2008). For an understanding of Kant's approach to psychology from the point of view of late 19th and early 20th century see Baldwin (1913).

CPR and Frege view psychology as an empirical discipline or, to be more precise, as a discipline dealing with empirically given humans.

3.2. The historical roots 2 – J. Müller and H. von Helmholtz

One can identify yet other historical roots of Frege's *oeuvre* when one turns to an example he uses to explicate the difference between his three worlds (realms). In *Sense and Reference* Frege reflects on the case of the observation of the Moon by means of a telescope by an astronomer (cf. Frege 1967b, 146-147), and he views the Moon itself as an entity outside the telescope (i.e., as the reference), the image created by the rays falling into the telescope as the sense, and the retinal image in the eye of the observing as the *representation* or *intuition*, which – by means of an (imagined) mirror – could be made visible both to the "owner" of the retinal image and to other persons. Here, as he did earlier, he states that different observers have different retinal images, while the images inside the telescope can be sent to several different sets of prisms and mirrors, and thus could be made accessible to other observers. So, the psychology which he has in mind is that of the physiology of human perceptual organs. That this is so can be seen in his article *Thought*, where he draws on the case of an (imagined) physiologist of perceptual organs, who investigates in the case when light rays pass through the eye and "strike the visual nerve-endings, and there bring about a change, stimulus" (cf. Frege 1967c, 355). And then he continues as follows:

> If a lightning strikes near us, we believe seeing flames, even if we cannot see the lightning. The visual nerve is in this case perhaps stimulated by electrical currents which occur in our body as a result of the lightning. If the visual nerve is stimulated by this means in just the way it would be stimulated by light rays coming from the flames, then we believe we see flames. It just depends on the stimulation of the visual nerve, no matter how it itself comes about. (Frege 1967c, 355-356)

Frege draws here explicitly on the knowledge of physiological psychology expressed already in J. Müller's *Handbuch der Physiologie*, who draws on the following three principles (cf. Müller 1840, 250-251):

> *I.* First, it must be kept in mind *that we can have by means of external causes no kinds of sensations, which we cannot have also without external causes through sensations of the states of our nerves* ...

> *II. The same internal cause causes in different senses different sensations according to the nature of each sense, namely, the sensible* [*Empfindbare*] *of this sense ...*
> *III. The same external cause excites in different senses different sensation, according to the nature of each sense, namely, the sensible of the respective sensenerve.*

And, as an example, he mentions in Müller (1840, 253), like Frege, the production of the sensation of a flash produced in the nervous system of a person placed in a dark room once the person is put in contact with two metal plates between which an electric current is passing, so that one plate is connected to the person's eyelid and the other is placed into his/her mouth.

Another possible source of Frege's examples of the physiology of the sight are the works of H. von Helmholtz, where Helmholtz gives a naturalistic turn to Kant's view on space as a pure form of intuition. He declares:

> *Physiological optics* is the science about the perceptions by means of the sense of sight. We see the objects of the external world through the mediation of light which proceeds from thence and falls into our eye. This light reaches the retina, a portion of our nervous system capable of sensation, and excites sensations in it. These, conveyed via the optical nerve to the brain, become the cause (*Veranlassung*) that our brain grasps the representation about certain objects distributed in space. (Helmholtz 1867, § 8, 30)

4. Consequences and objections

When Frege put into opposition thoughts and representations, this served, at least in my view, the sole purpose of opening the path to the ultimate aim of Frege's *oeuvre* – the foundation of airthmetics on logic, that is, the derivation of the former from the latter. But, this putting into opposition leads to several negative consequences which I will now subject to an analyzis.

The *first* and immediate consequence, once unified with the turn to physiological psychology in the spirit of Müller and Helmholtz, is that Kant's differentiation between the outerworldly forms of intuition (space, time) and understanding (categories) from the innerworldly (mundane) being of subjects, where, for example, their production of sensations are pro-

duced, disappears. In Kant's approach the sensations are viewed as the basis of cognition of the phenomena; but they turn into experience only when they are subsumed under a priori given forms of intuition and understanding. But once these forms are replaced by a description of the physiology of sense organs, the transcendental consciousness (Kant's *I*) is replaced by an empirical subject or, to be more precise, by a singular *I* which should be characterized by physico-chemical processes.[5]

Second, once that differentiation disappears, the issue of how to unify conceptually the two approaches to the *I* drops out completely from possible reflections and considerations. And, once a naturalist understanding of the *I* takes center stage, the possibility to make an attempt at such unification by means of a linguistic theory is completely lost.

With respect to this, Frege's views display the following specific features:

First, he argues that *language should play no role in the existence and functioning of representations*. Thus, each subject has his/her own representations which are mutually incompatible. But, curiously enough, when one looks more closely at Frege's example of the walk of an *I* (Frege) and his companion, the reader finds out (reads, that is, via *language*), that the *I* (Frege) is able to state "I see a green field with frogs on it and the Sun shining on it." So, *I* can let the others (the reader and/or *I*'s walk-companion) know what *I* knows, and thus they can compare their own representations with *I*'s representations. Stated otherwise, Frege does not take into account that language functions as "mirror" – using Frege's example with the telescope – making the representations of an *I* "visible," or – to be more precise – knowable to other *I*s.

Second, this implies that the social being of a particular subject, its ability to name himself/herself as an "*I*", should be completely independent of language. Thus, using again Frege's example of the mirror, he focuses neither on the possibility that language can function as a "mirror" making the particular *I*'s representations available and accessible to this very *I*, nor on the fact that the constitution of an *I* – via differentiation from other *I*s – somehow depends on the appropriation and use of language.

Third, Frege by introducing the logical entity *thought* and *sense* in general as expressed by language shared by humans, on the one hand, implicitly presupposed that language fulfills an *intersubjective* function: humans us-

[5] Here I draw on Gehlhaar (1991).

ing language can share thoughts which, he claims, are even passed from generation to generation. On the other hand, however, he did not reflect on the possibility that language could be the medium which enables the stabilization (reproduction) of the realm of thought both in a generation and across generations. Here, of course, one has to bear in mind that Frege did not reflect on the existence of an "intermediate category of the intersubjective. The subjective was for him essentially private and incommunicable; he therefore held that the existence of whatever is common to all must be independent of any" (Dummett 1993, 23).

Frege, given his orientation on logic/mathematics, focused on *that* psychology of his time which drew on natural sciences – physics, chemistry, biology, that is, on the so-called "scientific psychology" (see Baldwin 1913). For Frege, the science of psychology targets primarily the physiology (chemistry, physics, etc.) of perceptual organs. This is, at least in our view, at the basis of Frege's putting into opposition, on the one hand, the *objective content* of thinking (thoughts) and, on the other hand, the *subjective activity* of thinking. He views the latter as a *physiological process taking place in the nervous system and brain of an individual*.

This turn to a naturalistic understanding of the empirical *I* as well as the lack of reflections on the issue of the constitution of the realm of the intersubjective, even if they do not display their negative consequences in Frege's *oeuvre*, do so once the very empirical subject and his action become the subject matter of investigation; here I focus on philosophy of science and philosophy of social science of logical positivism/empiricism.

These philosophies are worth to be mentioned here because they were developed by individuals who worked simultaneously in the field of logic and related disciplines like logical semantics and who accepted Frege's realm of thought. So, for example, R. Carnap, not later than in his (1937), held to propositions as well as to other abstract entities (e.g., properties and relations), first as designates of designators in Carnap (1937) and then as intensions in Carnap (1947). At the same time, however, logical positivists held to a psychophysiological understanding of empirical subjects which,[6] on their part, led to an impoverished understanding of language of science and of scientific cognition. Here the following impoverishments are worth to be stated.

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[6] On this see, e.g., Carnap (1932; 1934b; 1938) and Nagel (1952).

First, this psychophysicalist understanding of humans as empirical subjects found its way into the philosophical analysis of scientific cognition produced by these subjects, so that attempts were made on the part of logical empiricists to reduce the latter to knowledge about the sensually perceptible state of affairs in the world. Thus, for example, in Carnap's *Testability and Meaning* as well as in Hempel's *Theoretician's Dilemma* attempts were made to eliminate terms which (they claimed) refer to nonobservable entities. As a consequence, in philosophy of science in the period when it was dominated by logical positivism/empiricism, a philosophical reconstruction of the structures of theoretical thinking was completely lost.

Second, that psychophysical understanding finds its way also into the analysis of language of empirical sciences. So, for example, in *Foundation of Logic and Mathematics* Carnap assigned to the terms (designators) like "red," "warm," etc. – which he viewed as atheoretic in their nature – designation, while the co-called theoretical terms (for example, "wave-function") were deprived by him of any designation and thus are not viewed as designators but only as elements of a calculus of words (see Carnap 1939, 67-68).

Third, that understanding led to an ever increasing split between the understanding of the logic of language and philosophy of science in the tradition of logical positivism/empiricism. While, on the one hand, that understanding underwent a profound development from logical syntax to logical semantics, first as a designator-designate and then as an intension-extension semantics,[7] philosophy of science in that tradition was not able to benefit from this development, and was trapped in attempts to differentiate between the theoretical and empirical. As a result, Carnap's project declared already in Carnap (1934a), namely, to unify "pure" logic with "applied" logic, where the latter should stand for an analysis and reconstruction of the language of empirical sciences by applying to them the former, was never accomplished.

5. Conclusion: A possible way out and lessons to be drawn

Given the above stated negative consequences of separating and in fact putting into opposition the transcendental subject and empirical subjects,

[7] On this development see Hanzel (2009).

the former being under investigation by logic and related disciplines (logical syntax, logical semantics), the latter by physiological psychology, one faces the question of *how to mediate conceptually between them*.

As one possible way out of this separation and opposition I mention here J. Habermas' attempt at a creation of a universal pragmatics,[8] which should provide a "[r]econstruction of the systems of rules by means of which we create or generate situations of possible speech in general" (see Habermas 1971, 102). Even if this attempt goes back close to forty years and was further developed neither by Habermas nor, to my knowledge, by any other linguistically minded philosophers, I still mention it here because it yields an understanding of the term "lifeworld" (*Lebenswelt*) which comes in certain aspects very close to Frege's realm of thoughts.

Habermas inherits this term from Husserl's *Crisis of European Sciences* but, contrary to Husserl, does not reduce it to a stream of intentional experiences but instead conceptualizes it as a "context of symbolic structures in the sense of interrelated communicative acts" (Habermas 1984, 48-49). This then allows him to give a sequence of delineations of this term; from the point of view of my paper the most important are the following.

1. The lifeworld is the correlate of processes of reaching understanding:

> Communicative acting subjects come to an understanding (*Verständigung*) always in the horizon of a lifeworld. Their lifeworld is built from more or less diffuse, always unproblematic, background assumptions. This lifeworld-background serves as a source of situation definitions that are presupposed by the participants as unproblematic. (1981, Bd. 1, 107)

And, like Frege, who presupposed the existence of a common store of thoughts being passed from one generation to another, Habermas states that the "lifeworld stores the interpretative work of previous generations" (cf. Habermas 1981, Bd. 1, 107).

2. The communicative actors as interpretators belong:

> ... with their speech actions to a lifeworld ... The structures of lifeworld lay down the forms of intersubjectivity of possible mutual understanding (*Verständigung*). It is to them that participants of communication owe their outerworldly position vis-à-vis the innerworldly, about which

[8] On this see his lecture "Universal pragmatics" in Habermas (1984, 83-103) as well as his paper "What is Universal Pragmatics?" in Habermas (1984, 353-440).

> they can come to an understanding. The lifeworld is, so to say, the transcendental locus (*Ort*) where the speaker and hearer meet. (Habermas 1981, Bd. 2, 192)

3.

> Whoever makes use of a natural language, in order to come to an understanding with an addressee about something in the world is required to ... commit herself to certain presuppositions. She must, among other things, assume that the participants pursue their illocutionary goals without reservations, that they tie their agreement to the intersubjective recognition of criticizable validity claims, and that they are ready to take on the obligations resulting from consensus and relevant for further interaction. What is in such a way embedded into the validity basis of language is also imparted to the forms of life reproduced through communicative action. (Habermas 1992, 18)

4. Finally, these presuppositions acquire with respect to particular participants of communication the character of transcendentally enabling conditions but, at the same time, such an intersubjectivistic or, in the terminology of Habermas, decentralized approach yields a changed concept of the transcendental consciousness (Kant's *I*). The latter "loses the connotation of an 'otherworldly' located in the realm of the intelligible. It has come down to the Earth in the everyday communicative practice" (cf. Habermas 1999, 26). This in turn enables to understand the condition under which Frege's (third) realm of thought exists: *It exists everywhere and only there where exists at least one species capable of communication by means of a propositionally differentiated language*.

Let me now state the following conclusions which follow from my paper with respect to claims about psychologism and antipsychologism.

First, since Frege's ultimate aim was to provide a foundation of arithmetics by means of logic, and thus also requiring the creation of an adequate logic, he had, prior to the realization of this foundation, to establish the conceptual and methodological autonomy of logic and arithmetics from other sciences, especially from the discipline labeled in the third quarter of the 19th century as "psychology." Thus, what corresponds to Frege's antipsychologism is the separation of logic and arithmetics from the above mentioned "scientific" psychology, that is, the view found in the tradition of J. Müller and H. von Helmholtz.

Nowadays, however, psychology is a discipline which is reducible neither to that physiological psychology nor its modern forms. Here I have in mind especially social psychology in the tradition going back to, for example, G. H. Mead, J. Piaget and V. Vygotsky, and which deals with the social and socio-linguistic constitution of human beings (see, e.g., Friedrich 1993; and Hollin 1995). So, any charges of psychologism raised against views stated in logic, philosophy of science, philosophy of social science, etc., have to be always accompanied by the delineation of the type of psychology that the person raising these charges has in mind.

Second, the same holds also for particular antipsychological claims like, for example, "Representations are the subject-matter of investigation by psychology". While for Frege psychology was physiological psychology, the present state of psychology as a discipline requires a modification of this claim into the form "Representations are the subject-matter of investigation by this and this type of psychology." And this in turn requires knowing in advance, whether this psychology employs the term "representation" at all and if so, then how it understands this term.

Third, and finally, till now I have used the term "psychology" in the singular. But given the fact that there exist different approaches in psychology which are not reducible one to another,[9] this singular is nowadays in fact inappropriate. One should instead use the plural form "psychologies."

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[9] On the relation between different approaches to psychology from the point of view of metatheory see Madsen (1988).

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