STUDIA UBB. PHILOSOPHIA, Vol. 63 (2018), 2, pp. 63-91
(RECOMMENDED CITATION)
DOI:10.24193/subbphil.2018.2.05

ENACTIVE THEORY OF RADIOLOGY IMAGING: IMAGES AND LANGUAGE AS DIAGNOSTIC TOOLS

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ABSTRACT. The article is based on research conducted at Le Bonheur Children's Hospital, Radiology Department (Memphis, Tennessee, USA). It examines embodied cognition embedded in radiological diagnostics relating image perception with normative judgment constitution. The research follows the causal thesis in that it is possible to grasp categories and causality via visual experience (causal impressions) and language (causal verbs), which in turn heavily depends on strategies of the enaction of imaging technology and intersubjective corroboration. In this way the pre-reflective and intersubjective constitution of categorial fulfillments of diagnostic experiences is disclosed by phenomenological ethnography of radiologists' praxis showing how professional knowledge is structurally interrelated with certain kinesthetic and kinetic experiences, multilayered image apprehension and enactive metaphors.

Keywords: Enactivism, Phenomenology, Radiology, Diagnostic Imaging, Causality

> "We define something by its style of becoming, not by its already given forms." (Deleuze, *Cinema II*).

Introduction: Phenomenological Ethnography of Medical Imaging

Medicine with both its scientific and practical aspects as well as giant leaps in technology development offers a rich field for applying ethnography and extending phenomenological ideas in experimentally unaltered life-world conditions. Radiology as one of the most developing branches of medical image-based diagnostics rests heavily on a specific type of imaging which is still evolving and has multiple modalities. Maybe it is because technologies and praxis are evolving so fast, radiologists' experiences conditioned by this imaging as well as medical and biological knowledge

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and determined pragmatic tasks was poorly investigated. Historically phenomenological ideas were applied to the field of psychology and psychopathology (Binswanger, Frankl, Boss, Fuchs, etc.), especially from the "patient's perspective" rather than the therapist's perspective. Although even when the "diagnostic perspective" was concerned, investigations took the form of psychophysical experimenting (looking for sensual "thresholds" in visual experiences) or Gestalt psychology (Nodine and Kundel 1987; Oestmann 1988; Andriole 2011; Maeda 2013, etc.). Both had their respective success (for example, famous "Gorilla" experiments (Drew 2013) but our aim is to show that phenomenology especially in its embodied enactive self-interpretation via ethnographic methodology may expand the understanding and even aiding of image interpretation in radiology. Although we cannot answer all questions that such an ambitious goal presupposes, hopefully we will provide a comprehensive framework to deal with them.

Phenomenological ethnography enters the field of everyday praxis of radiologists. In that respect it differs form any experimental approaches and relies on first person observations of radiologists' interpretation of images. Here radiologists' lived experience (*Erlebnis*) of the diagnostic process is brought to the researcher's attention in a step by step analysis, talking through important but usually un-reflected points, trying to embrace all the details of actual praxis with its epistemological, social and environmental specifics. This does not mean that the vocabulary of psychophysics or Gestalt psychology cannot be recognized and used in phenomenological settings; on the contrary, the insightful findings of such approaches concerning perceptual patterns, visual coping, etc. might and need to be re-contextualized via phenomenological ethnography. This "re-contextualization" includes concentrating on the pre-perceptual (affective) genesis of the perceptual acts and also on the perceptual "objects," conceived as pragmatic affordances determined by the specific mode of givenness (Imaging). Finally, phenomenological ethnography stresses the specific character of region concerning knowledge, which is very important in medical praxis, oscillating between anatomical, histological and biological generalities. What are the essential characteristics of diagnostic process? How does imaging determine the appearance of siagnostically relevant data? What are the perceptual and cognitive acts that correspond to such modes of appearance and ground diagnostic outcome?

Despite the unearthly character of surroundings created by the macabre abstractions of imaging, radiologists like any social subjects are immersed in the "natural attitude" in terms of concentrating on the task at hand and not on the experiential processes that lead to the more or less successful accomplishment of that task (Dreyfus 2014). When asked to reflect about the actual performance radiologists

sometimes compare it to a dream like undifferentiated state.[1] Medical literature for that matter is more specific but draws heavily on few explanatory schemes, which contradict phenomenological observations. Diagnostic process is usually described as based on the ever accumulating storage of relevant normal and abnormal cases (images) and diagnostic outcome is due to the inference on the basis of successful retrieval and comparison of those cases from the professional storage (Lawson and Daniel 2001; Balogh et al. 2015, etc.). Such a retrieval might be innate or learned. Although I understand how concepts may vary from discipline to discipline, it looks like this summary of diagnostic mechanism describes representational and inferential model of image-based diagnostics, which may not correspond with the phenomenological ethnographic data. In order to gather such a specific, experiential, first-person data phenomenology uses the method of phenomenological reduction, which differently from natural sciences and/or psychology does not reduce the phenomena at hand but in contrast suspends all unnecessary conditions for that phenomena to show itself in full depth.

1. Enaction of Radiology Images

1.1. Three Levels of Apprehension

In *Analyses Concerning Passive Synthesis*, Husserl characterizes apprehension in this way. Apprehension is an ‘‘achievement of consciousness’’ that enables the ‘‘merely immanent content of sensible data, the so-called data of sensations or hyletic data ... to exhibit that which is objectively ‘transcendent’’’ (Hua XI, p. 17). The outcome of apprehension is certain aspect, angle, position of the object at hand. Concrete diagnostic task or sub-task will work as an instruction for how to perceive a sensual data, how to approach sensual features localizing and identifying them. Then apprehension which defines the right adumbration of an object is a cognitive capacity in the midst of perception, it is already an interpretation of sensations in the perception of relevant objects.

When we look at the picture, according to Husserl, we are “using” Image-consciousness to relate two levels of apprehension – *Image-Object* (image which we perceive) and *Image-Sujet* (that which serves as the true referent of a picture, the content of an image), while the physical substrate usually remains purely transparent for the layperson. Although radiologist operates also on the so called first level o apprehension radiologist evaluates the quality of radiologist image

[1] From phenomenological point of view such states do not mean that this person is not mindful because phenomenology does not equate mindfulness with attention (Jacobs 2010). Contemporary phenomenology views skilful coping as mindful and social (Gallagher 2017b).

which also include patient positioning correct for each projection, that the images were not blurred and that optimal image density would be visualized. Patient positioning is guided by normative categories, such as straight, left-right, up-down, etc. During the quality check of an image is done reflectively, radiologist avoids fixing onto objects or spaces between objects, instead, she tries to see it as a continuum of impressions. If poor quality interrupts the process of visual search without previously being checked, it is kinesthetic sensations as the feedback about the quality of the process that force radiologist to adapt bodily position (In the case of radiology eye movement is predominant kinesthetic sensation, but also head movement, hand-eye coordination, distance between the screen, gestures) or to stop the whole visual search or change the modality of differential diagnostic judgment (uncertain, probable, most likely negative, etc.).

Second and third level of apprehension (Image Object and Image subject or content), due to the abstract and minimalist character of medical imaging, demand another skillful coping because Image Object does not correspond to some exact original beyond the image and the Image content is not an entity but rather a complicated process of biological abnormality. On the one hand, Radiologist may focus on the Image Object (which is not an everyday practice of experiencing images), concentrating o the basic features as they are presented via image modification, intuiting diagnostic situation beyond sensually given data. On the other hand, knowledge and anticipation of Image Subject enables to reframe visual field and capture just basic clues, such as localization and texture changes needed for the intuition of complex categorial situation, which transcends visual field (see further).

Switching apprehension levels in medical diagnosis shows that the ability to neutralize the conflicts between these levels as well as kinesthetic feedback about the level of motor “maximal grip” (Ponty 1962) are the parts of radiologists’ professionalism. Knowledge of radiologist enables to apprehend sensations in a way to get the adumbration needed for diagnosis. But while discrete features might disclose the complicated scenario (basic features) of the disease it is more common for radiologist to form an anticipation which would transcend the sensual content given by image but nevertheless guide her act and motor intentionalities (apprehension and movement). Following Aristotle (1901) and Husserl (1973) we call this kind of anticipatory structuring categorial, meaning that the confirmation (or canceling) of diagnostic anticipations, while founded in sensual data, rest on complex categorial relations peculiar to medical and biological regions of knowledge (Smith and Grenon 2004).

In radiology an image never stands alone, it is supplemented by other images (usually, earlier checks), clinical guidance and general patterns of particular pathology. This means, that radiologist is able to apprehend “relational aspects” (Blederman 1988) of an image, when certain features disclosed by the image make

sense only in relation to spatiotemporal anatomical and/or histological changes (see further). Radiologist may directly sense such higher order properties as symmetry or homogeneity (Treisman 1986). Locating a feature is separate operation from identifying it and could logically follow instead of preceding identification. The identification works for discrete features, but *conjunctions* (categorial structures) are grasped initially as localisations. When conjunction is localised (usually, as *dis-location* in medicine, i.e. deviation from norm) a lot of visual stimuli becomes unattended and registered only on a feature level (for example, words in relation to sentences). Distractors might be identified without being localized and have behavioural effects even being unattended. Experienced radiologist locates conjunctions while reducing unnecessary features via variation (factual, depending on imaging modality) and skilful framing. Light might be thrown on the main focus feature but others as horizon, as spatial relations, makes possible the localisation of categorial conjunction. This grasp of conjunction is an impression of categorial causation being founded in basic features. These are few examples:

Spiculous/round
Dislocated/in place
Bright/dull
Vertical/horizontal
Oversized/undersized

Examples of apprehending conjunction via the experience of dis-location (also see Figure 7):

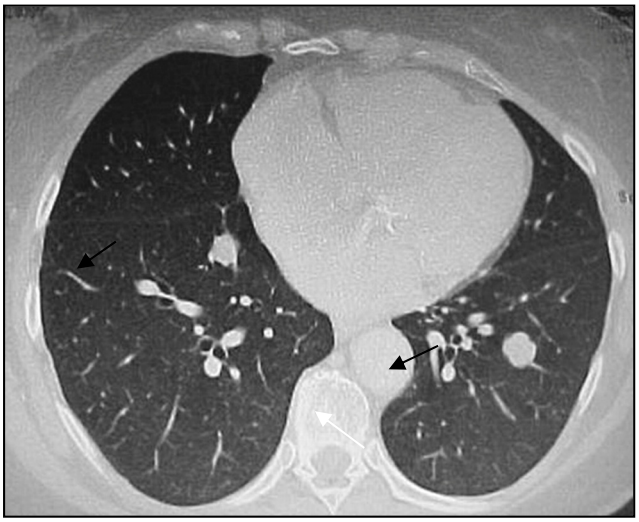


Figure 1. Chest CT.

When several masses detected in the lung parenchyma tissue, radiologist can relate them together in suspicion of metastasis (black arrows). Although features (identification) of pulmonary vessels and metastatic tumors are virtually the same, pulmonary vessels, visualized also as masses (white arrow) are in typical location and have continuation on the next slice (image), if enacted by radiologist, when metastatic tumors are located atypically or dis-located. Finally, secondary (metastatic) tumors, detected by the enaction of this image presuppose the primary tumor which may be situated elsewhere, for example, in kidney or breast.

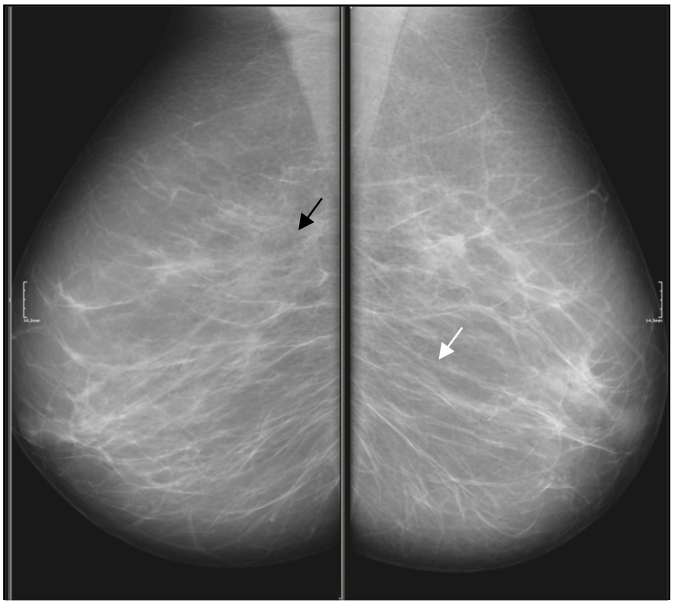


Figure 2. Mammograms.
Spiculated mass on the left MLO mammogram (reader's right) in the upper lateral quadrant of the breast (black arrow). Tissue superimposition imitating mass near the nipple (white arrow). Tissue superimposition may seem as cancer although radiologist grasps real cancer because it is experienced as separate (from other structures), later experience being founded in the (causal) impression of spiculated contours (see further).

1.2. Experience of Causal Categories via Radiology Images

Dis-location/identification experiences show that, as Husserl suggested already in *Logical Investigations*, sensual affection that awakens and motivates categoriality and modalization is a necessary but not sufficient condition for the grasp of a categorial situation (*Sachverhalte*); it is the grasp not of objects but of

very categorial and even causal relations in the process conditioned by the regional (medical, biological) ontology. The biological realm of medicine consists of things possessing extensive and intensive magnitudes, being in states at particular moments in time, and undergoing mutations or perpetuations of state according to causal laws.[2]

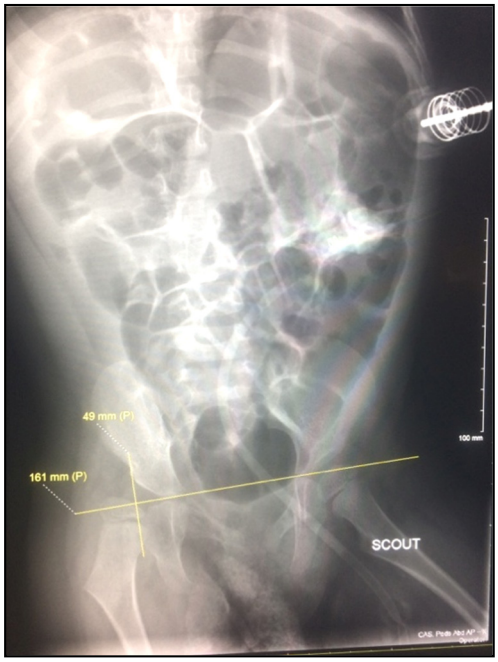


Figure 3. Abdominal X-Ray.

Radiologists' description of the categorial norm and the experience of dis-location: "Hilgenreiner's line is the horizontal line which is drawn through the upper margin of the triradiate cartilages. Perkin's line is the vertical line drawn from the most lateral edge of the acetabular roof and perpendicular to Hilgenreiner's line. In a normal hip, the ossified capital femoral epiphysis is positioned medial to Perkin's line and inferior to Hilgenreiner's line (i.e. inferior-medial quadrant). In a subluxated hip, the epiphysis is positioned lateral to Perkin's line and inferior to Hilgenreiner's line (i.e. inferior-lateral quadrant). In a dislocated hip, the epiphysis is positioned within the upper-outer quadrant (i.e. lateral to Perkin's line and superior to Hilgenreiner's line). If the capital femoral epiphysis is not ossified, the medial edge of the proximal femoral metaphysis is utilized".

[2] "Cause" does not have a clear-cut meaning in mechanics. In the latter, we have instead a whole theory, called dynamics, consisting of several concepts (mass, force, momentum, elasticity, viscosity, etc.) and a set of equations for their application, which together cover the causal aspects of mechanical events. To talk about *the* cause of an event is therefore quite pointless (Runeson 1983: 34).

Husserl mentions the “universal causal style of nature” in correlation with human habits of apprehension. Nature has its “style of appearing”, which is basically causal, and this determines, for example, at least some habits of the radiologist, habits of interpretation (Moran 2011: 69). The radiologist habitually grasps the whole causally determined deviation from a biological norm, and this experience resonates with the traces of a causal impression left on her body after everyday interactions but which has been extended to the categorial apprehension of biological causality. Everything empirical must embody these categories, but it is only normative social anticipations that determine what categories will be detected in the empirical realm. Check this report:

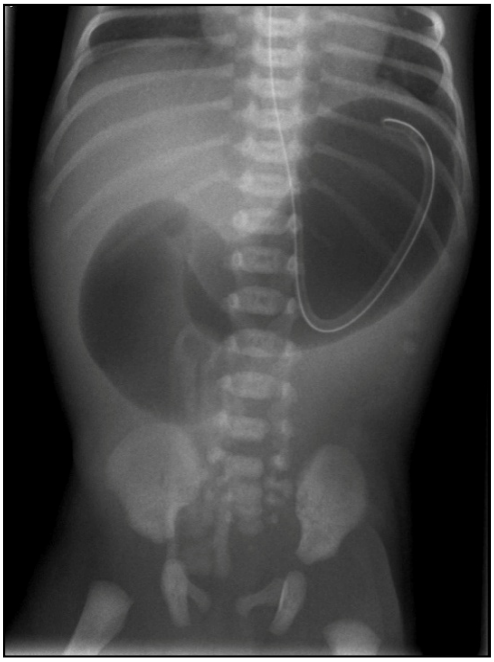


Figure 4. Abdominal X-Ray.

Radiologists’ report: “An enteric tube is in place with the distal tip in the fundus of the stomach. There is a "double bubble" sign with a moderately dilated stomach and markedly dilated proximal duodenum. Normal situs without visceromegaly is noted. No abdominal mass or abnormal intra-abdominal calcifications are seen. No pneumatosis, portal air, or biliary air is identified. No free intraperitoneal air is seen on this supine examination. The included bony structures are intact. No pathology is seen at the included portion of the lung bases. An upper gastrointestinal examination is recommended for further evaluation”.

Enacted by imaging causal impressions (bubble, dilation, being intact, etc.) found the categorial experience of human or cancer intervention. This categorial pattern leads radiologists visual search and serves as the main strategy of image apprehension until the examination of unattended areas (because of "satisfaction of search" danger), but the findings of this subsequent examination have a modality as "less likely".

A category articulates the object as relational; it enables the discourse to express, in a syntactically formed expression, the categorial object, rather than merely naming the underlying object. The diagnostic objects possess causal properties, that is, properties that, while sensible, are grasped either as the effects of the causal agency of other objects or properties that produce effects in other objects. Medical imaging varies and presents those properties that are the effects of other objects, as well as those properties that can causally affect other things. The material thing, then, is the identity in the manifold of its sensible appearances and properties, and it is the identity in the manifold of causal relations. Husserlian categorial intuition (apprehension of categories) in radiology is an accomplishment of embodied cognition and social normativity: it depends on the enaction of empirical imaging tools. Categories must be enacted; the radiologist grasps diagnostic categories by enacting imaging modality, performing visual searches, navigating, measuring, changing perspectives, and even imaging modalities. Enaction means that the radiologist grasps causal categories of biological deviation not by pictorial consciousness, but by action—the externalization of memory by the enaction of imaging technology and image-consciousness. I call those founding experiences of categorial intuition *causal impressions*.[3] The crucial epistemological question now is the following one: Is it possible to experience causality via imaging?

While experimenting with visual stimuli, Albert Michotte (1963) showed that imaging is able to convey the experience of causality as direct and not inferential. What is a causal relation, according to Michotte? The relations of pushing, pulling, lifting, stopping, moving, supporting, hanging from, and preventing something from happening should be considered as modes of causation: they are specific ways of causing something else to happen. Causality always has a

[3] The very word impression ("to be imprinted") probably belongs more to the tradition of Proustian subjectivism than phenomenology; still it signals a non-representational stance and the importance of sensual content of embodied cognition. Impressions are based in real kinematic experiences, although the images are given "as if" they were real. An "impression of cancer" then would be more kinematic than visual, i.e. first, it would be localized according to the categorial spectrum of possible pathology, and then identified (although sometimes localization remains the whole degree of identification). Phenomenologically, localization discloses the genetic origination of the static identification. Identification would come first if we were to live in a static, eternal act.

structure, which reveals itself passively as categorial intuition not only through higher-order cognitive concepts. This is how image-consciousness and the experiential impression of causality stimulates the scientific one.

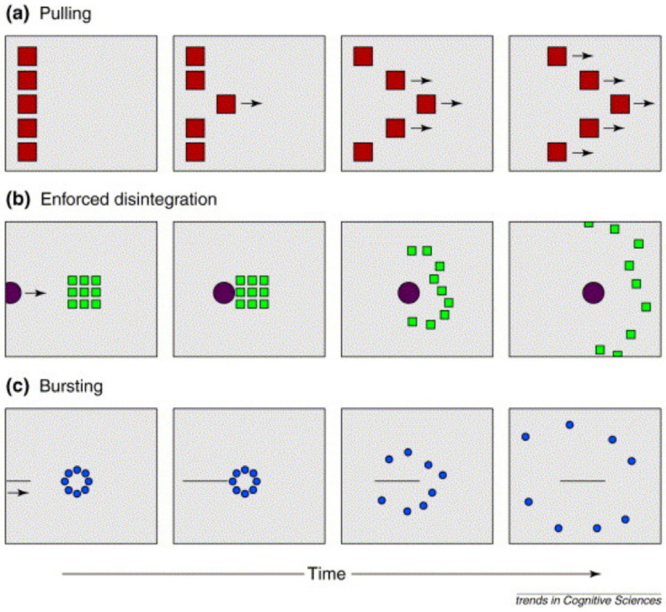


Figure 5.

This perception of causality in turn reveals the radiologist's body as motivated such that perception and self-apprehension (kinesthesis) go together. Michotte showed that while people perceive causality in abstract conditions, they still found this experience in everyday motor coping schemas. According to Michotte, all social interpretations and communications rest on basic kinematic impressions, that is, impressions of motion that correlate with bodily schemata of impressions of the interactions with physical objects. Kinesthetic systems are formed from worldly experience, so we perceive ourselves as combining impacts on and from various things. These constitutive experiences are also part of visual perception. Hence, causal relations may unfold in a great variety and the experiences of it does not need perception of a direct contact. This prepares us to view medical imaging as the setting for the embodied and intersubjective enaction of basic categorial impressions that ground diagnostic knowledge. At this point, it is crucial to distinguish between quantitative and qualitative causal categories.

Categorial causal forms in the medical-biological realm can be divided into two main groups: quantitative mechanical and qualitative biological.

Quantitative causality (broken bones, dislocated organs, etc.): impressions of ampliation, pushing, bursting, penetration, enforced disintegration, obstruction and others.

Qualitative causality (cancerous processes): change in a property of an object without the visual perception of impact, impressions of temporal sequences of disease development—order/disorder, growth/reduction, formation/deformation, action/reaction, etc.

Perhaps the best way of demonstrating the possibility of quantitative causal impressions was delivered by Michotte's followers, for example, Tremoulet 2000, Scholl 2000, who showed that rather abstract visual stimuli can motivate the impression of animated action, even emotional charge (see Figure 6).

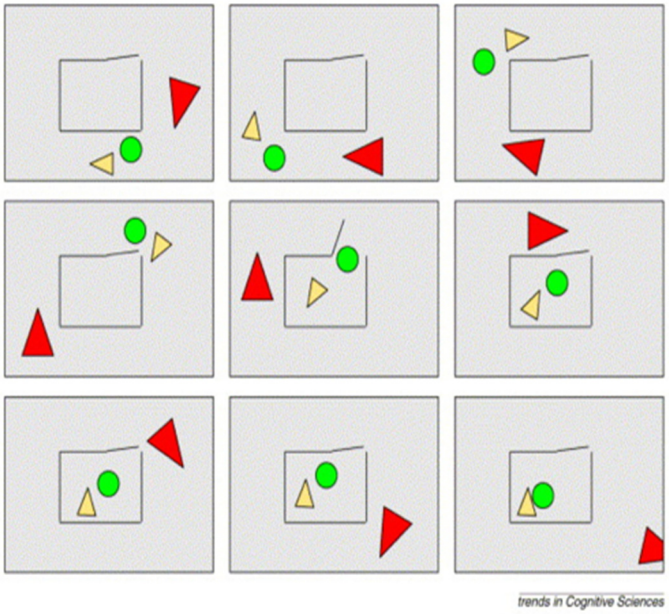


Figure 6.

They showed that even inorganic structures under some visualization may be taken as possessing some animated, i.e. goal-oriented, meaningful, emotionally charged intentions and actions. If we apply this idea to medical imaging, we may speculate that the biological objects presented by medical images disclose themselves as belonging to some higher-order processes and structures. As organic parts of biological processes, some entities are taken as animated beings

endowed with “primary subjectivity”, which includes teleological interactions with the environment and participation in greater narrative processes (for example, metabolism[4]).[5]

1.3. Causal Impressions and the Enaction by Measuring

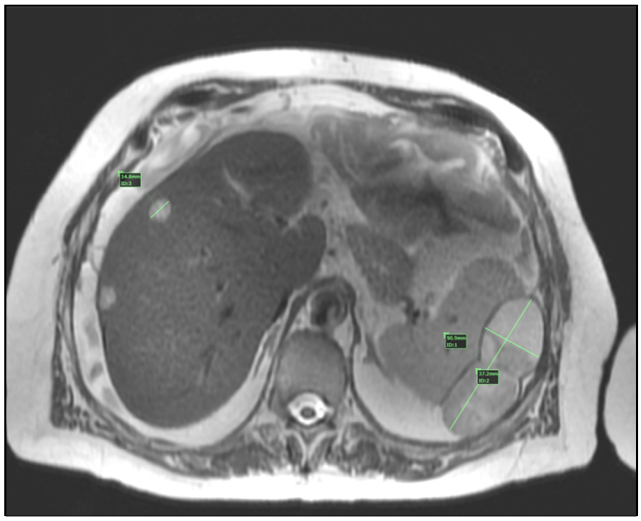


Figure 7. Abdominal MRI.
Measured abnormal masses – on the left (to the reader) there is a intraparenchymal mass *in* the liver, *surrounded by* liver tissue, suspected metastasis. On the right *in* the abdomen – the metastatic mass *behind the* spleen, *between* the spleen and the abdominal wall.

Categorial intuitions need to be enacted by technology in order to turn them into signs of exact (not “more or less”) normative value. Hence, after initially grasping dis-location (*in*, *surrounded by*, *behind the*, *between*, etc.) the professor sets the first dot on the border between the spleen and the suspicious mass and draws the thin green line until he fixes the second dot on the abdominal wall by unclicking the right mouse button. Small numbers under the line appear instantly after the fixation movement and show the exact measure—the sign now can be compared with the standard. As I see it, the line connects two points of relation, which earlier made up the categorial impression “too wide”, or we might also say, more generally, experience of dis-location as “something’s wrong”.

[4] See on phenomenology of metabolism in Barbaras (2010).
[5] See more on the relation between animacy impressions and diagnostic process in part 2.

Radiologists' report (see Figure 4):

> I do measure several parts of anatomy. For example, the width of a dilated bowel loop, **if it is markedly dilated** (small bowel or large bowel…the large bowel is the colon). One could have measured the width of the dilated proximal duodenum in this case, but it is not necessary. Stating that it is **markedly dilated** is sufficient as it is a component of the 'double bubble' sign.
> I would measure the size of a mass in the abdomen or in an organ (e.g. the liver). I would also measure the size of a lesion in a bone. One can also measure the distance of the distal tip of an endotracheal tube from the carina (the branching point of the trachea into the right and left mainstem bronchi). This is commonly done. The Cobb measurement tool is commonly used to measure the angle of a curve in the spine (i.e. scoliosis).
> I like the measurement tools that we have on our PACS system. I would prefer different methods of deleting measurements/angles, but it takes many requests for a wish to be accommodated by the vendor.

Consciousness of images, according to Husserl, gives us, for example, shapes and shades that are more or less straight, circular, dense, transparent, etc.[6] In radiology imaging this "more or less" experience is very intense. There are no sharp boundaries between objects, hence their experience relies on (categorial) intuition which transcends perceptual givenness. If, however, categorial experience is not enough radiologist must enact other means of diagnosis, i.e. measuring.

The example above is just another "enactive proof" of the primacy of categorial experiences. It concerns how and when a radiologist enacts the measurement technology. Before the measurement and interpretation of imaged objects as "signs", there is an experience of categorial relation ("too wide", "dislocated", "obstructed", etc.), which is always "more or less" ("something is wrong"). In the highly abstract environment of radiology imaging, there is simply no possibility to grasp clear signs only via measurement techniques, so the continuity of shades must be eliminated by the categorial intuition (radiologists' experience) and not semiotics of isolated features signs. This "more or less" character of radiology imaging demands the primacy of categorial intuition. If it were otherwise, then the so-called "secondary interpreter" (CAD, computer aided detection) would perform radiologists' tasks far more efficiently. Although CAD is useful in double-checking diagnoses—for example, breast cancer—it may well detect tumors in an image of the sky.

[6] See in this regard, Husserl's refection on Galileo's scientific approach in "Crisis" (Husserl 1970).

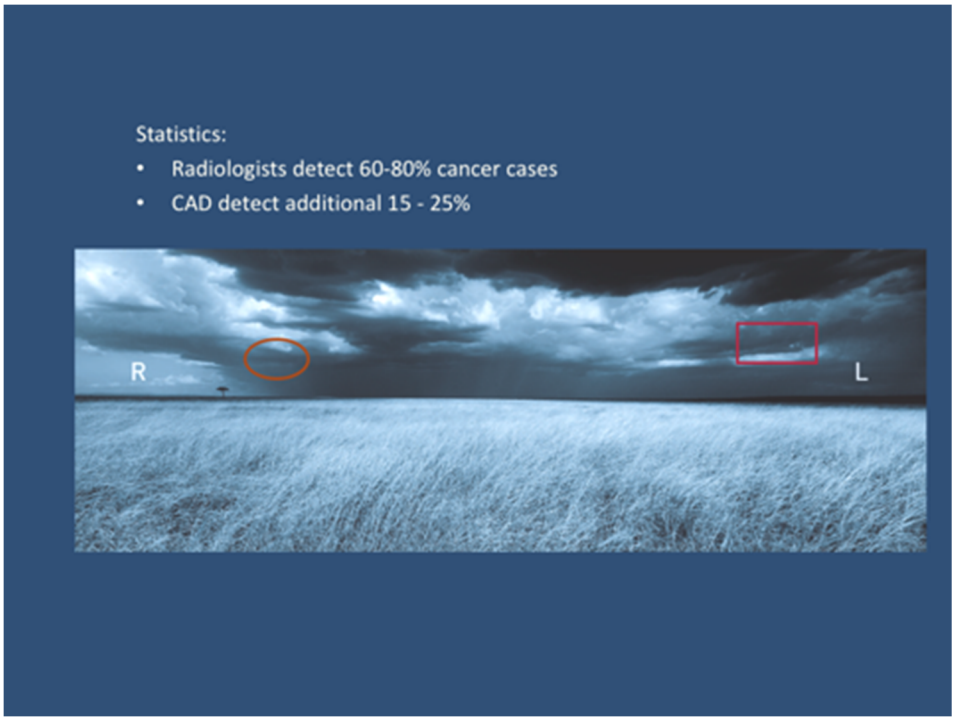


Figure 8.

However, the radiologist may translate an impression into a sign via measurement. Measuring is the compound operation of enaction by which categorial impressions of medical images are translated into signs, and as such they are compared to socially established "ideal" types. Although an individual radiologist experientially grasps the subtle gradation of imaged objects, the normative evaluation (almost) always remains within the horizon established by institutionalized science. The radiologist does not seek an absolute identity, an ideal representation, because, following Husserl, it is precisely these ideal forms that are missing from the sensible qualities. Sensible qualities for the radiologist are impressions of categorial causality, not the material stuff for filling in the platonic *eidos*. So, in the life-world, the sense qualities are not signs of *eidos*, but actual experiences of (categorial) "things". The sign is a matter of measuring science, not life-world experience, and though the latter can follow and confirm the former, it does not apply the ideal form of cancer to the appearance of cancer.

Measuring by enaction is yet another tool in completing the normative identification of an abnormal situation, but it is preceded by the experiential grasp of dis-location. Identification of those marginal points of categorial relation is a

secondary, more reflective operation, which demands good hand-eye coordination (unlike the visual enaction of categorial impressions). Enaction by measurement does not usually create a causal impression because it is rarely an affirmation of that impression (which might boost the causal impression for the novice radiologist); instead, it is already a step of data processing as the translation of categorial impression into non-sensual sign, signitive expression (Husserl 1973). Such processing enables impressions to be externalized up to the level of medical standardization and diagnostic propositions.

We can put this in even stronger terms: if to mathematize nature requires that we treat sensible qualities as signs, then to mathematize nature betrays what Husserl has called, in Ideas I, "the principle of all principles", and this is the core principle of phenomenology and, indeed, of philosophy in general (Husserl 2014). This principle instructs us to accept as evidence only what is intuitively (not semiotically) given. Although signs are sensual, they do not provide the experience of causal relations as images do. They can point to the latter, but they cannot be the source of it. Measurement may boost the externalization of professional memory and the experience of causal relation when the feedback is poor and modalization is uncertain—for example, in cases of an inexperienced radiologist, a lack of visual perception skills, poor image quality, a lack of clinical information.

If, by way of feedback, the radiologist experiences poor affordances and modalization of categorial impression—such as "doubt"—then enaction of measurement becomes an extension of that impression and delivers the experience of (normal or abnormal) causal relations.[7] If, as in our case, affordances are intact and modalization is "certain", then measuring becomes a distinct, secondary act by which the professor accomplishes "higher-order" tasks. From this he can compare this particular measurement with the standard, and use it in diagnostic propositions.

1.4. Amodal Completion and Visual Search Patterns

Bringing together causal impressions, categorial patterns and search patterns strongly suggests that the basic principle of image apprehension in accordance to visual search patterns in most cases of radiology is *amodal completion*.[8] Amodal completion is not a visual pattern, it is a mechanism who brings categorial intuitions and visual search patterns together. For example, this form of completion of the black shape behind the gray occluder was referred to by Michotte as *amodal completion* (Michotte et al. 1991). While medical images are altered in order to highlight the

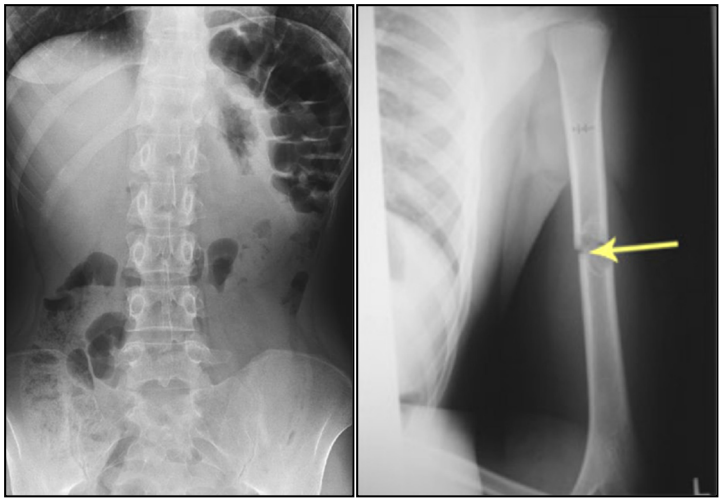
[7] If there is a lack of perceptual and clinical information concerning particular image radiologists' decision still depends on many other factors, for example, emotional wellness of a patient and federal funding for the screening program, so she may ask to show up for the next examination after six months instead of a year.

[8] See, in this regard, Nanay 2007.

essential relations between relevant objects, they are very poor concering percetual information so radiologist still needs to skillfully apply motor and apprehension schemas in order to amplify complicated causal patterns. Amodal completion fulfills not only discrete features of partially hidden objects but also causation, temporality and social importance and even empathy for primary subjectivity.[9]

Amodal completion is in dialectical relation with categorial form. On the one hand, by imagining it completes perceptually obstructed pieces of pathological process or human activity (for example, when the end of *esophagus* is "wrapped around" in order to control reflux) which determines categorial situations. On the other, categorial intuition directs which entities and/or relations need to be completed. "The world" of biological processes is perceived by radiologist as a surrounding plenum, even though only part of it is in view at any time. Visual patterns of radiologist may be influenced by the general biological regularities, for example top-down structure of a blood flow and looking for the "travelling tumors" (examples of angiogenesis, metastasis). Also amodal completion depends on the degree of the sense of guidance, that is technical quality of an image and clinical information that accompanies an image. I argue that completion is accomplished by quantitative and qualitative causal impressions. Here are few examples how visual search rests on categorial experiences.

Causal Assymetry



Figures 9, 10. Abdominal X-Ray and Bone X-Ray.

[9] The term "amodal completion" is coined out of and balances two other terms – amodal perception and modal completion. It is better to say completion than perception because the whole is grasped as causal categorial relation, temporal span.

Causal asymmetry pattern consists in experiencing one phenomena as caused by the other without any perceptual evidence of a direct contact and qualitative similarity. In the figure 9, perception of a lower density mass in the upper body area means the obstruction of the intestines in the lower area. Figure 10 represents broken bone due to the bone tumor.

Common fate is another example relevant to radiology. Here objects that *move* in the same way tend to be grouped together. Sekuler and Bennett (2001) presented an extension of *common fate* to grouping by common luminance changes. They found that when elements of a visual scene become brighter or darker simultaneously, even if they have different illumination throughout, observers have a powerful tendency to group those elements perceptually, which is the occasion in radiology (*see Figure 11)*.

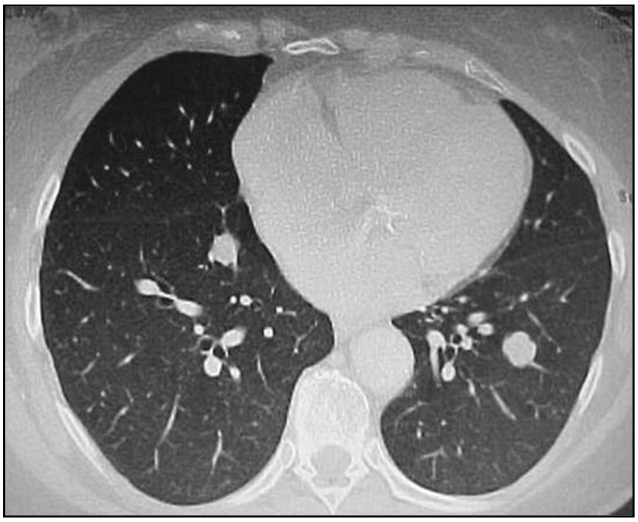


Figure 11. Chest CT.
Because of the knowledge of categorial unfolding of cancer radiologist can relate several masses together in suspicion of metastasis, although features of a single (primary) tumor and metastasis (secondary tumors) are virtually the same.

These examples illustrate how *visual search* patterns are guided by the initial categorial intuition.[10] It is necessary to add that because of the danger of the *satisfaction of search* errors visual search patterns in radiology must be switched after accomplishing the initial search in order to seek for "secondary findings".[11] Finally, it is crucial that in radiology these Gestalt type patterns work

[10] It is possible in this context to discuss other Gestalt principles of grouping (such as *similarity*, *proximity* or *closure*) as well.

[11] For example, after the *Eventration* is diagnosed, expectation of *Hernia* as a secondary finding (when the primary one is *Eventration*) guides subsequent visual search.

because they are normatively contextualized (due to the knowledge of particular pathological categories and clinical information) and personalized by the enaction of imaging technology, which means that there is a dialectical relation between the knowledge of pathological categories and the enaction of imaging technology. On the one hand, radiologist chooses imaging modality, perspective and even the temporal sequence of diagnostic images according to a particular pathology, but at the same time enactive operations disclose those portions of image material which confirm categorial relations. Obviously, the full overview of visual patterns relevant to radiology deserves a separate study.

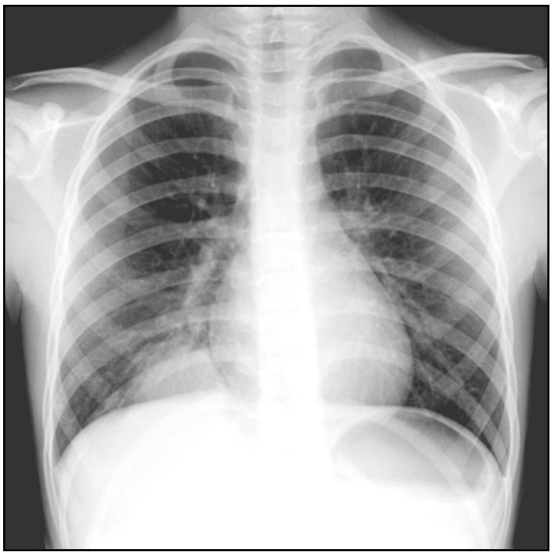


Figure 12. Chest X-Ray.
Diaphragmatic eventration is a congenital condition in which a portion or all of the diaphragmatic muscle is deficient. Where the muscle is absent, a thin membrane replaces the normal diaphragmatic muscle.

1.5. Neutralization of Conflicts between the Enaction of Apprehensions

Switching between apprehension levels demands from the radiologist a strong mechanism of conflict resolution. A "switching pattern" might be disrupted for a number of reasons, whereby the radiologist experiences feedback in the form of a conflict.[12] The reasons for this may be the lack (or surfeit) of affordance of concentration (managing switching patterns) resulting in abandoning the

[12] By "switching pattern" I mean both the enaction of imaging and other diagnostic technology (templates, recorders, etc.) and changing levels of image apprehension.

diagnostic process and returning it to clinicians or a technician, a diagnostic mistake, a lawsuit or emotional disturbance.

For medical images, the consciousness of conflict (*Widerstertbewusstsein*, Hua XXIII) is very peculiar, because conflict may appear on or in between any level of image apprehension. Conflicts also depend on enaction strategies—some are more likely while others almost never interrupt the diagnostic process. Such conflicts include:

Between the unreal character of an image and one's actual surroundings (image apprehension and marginal surrounding);

Between abstract image and real referent (suspension of a natural attitude by image affection);

Between the first and second levels of apprehension (quality of an image);

Between the second and third levels of apprehension;

Between clinical information (guidance) and the whole image apprehension (ownership);

Between different sensory modalities (vision, touch, audio);

Between different enaction tasks (seeing, reading, typing, speaking, scrolling, etc.);

Between 2D and 3D modifications of image apprehension;

Between categorial experience and measurement.

As we have seen, these binary oppositions, in truth, are possibilities for "switching patterns", but they may also take the form of a severe conflict. This also means that the lack of "anesthetic" affection by medical imaging and intersubjective corroboration may gravely affect the prosthetic enaction of diagnostic tools. For example, this could result in the inability to keep to the relevant thematic attitude at every conscious moment of the diagnostic process.

The notion of thematic attitude and thematic field (Gurwitsch 1957) is of crucial importance to the evaluative abilities of the radiologist. Thematic attitude, unlike the natural one, must demarcate a certain region of interest (Smith and Grenon 2004) and fulfill this interest according to the material ontology of this particular region of being.[13] If the thematic perspective is loose, the evaluator will have some trouble in deciding what should be counted as relevant, and an impractical orientation to the world, or rather part of it, would appear. It is known in psychopathology, where the whole world as the horizon of horizons may become

[13] For Husserl, the "material ontology" is one whose scope is restricted to a particular kind of thing. The limitation is grounded in a determinate and essential material content. At the highest and most general level, this determinate material core is a region; at lower levels it is a genus and then a species" (Drummond 2007).

a challenging experience, a sort of "affection by reality" (Murakami 2005), whereby without the sense of thematic concern, one can loose the ability to organize larger units of meaning. Hence, as with neurotic disorders (though to a much smaller degree) possible mistakes by the radiologist can fall into several categories, depending on what is causing a "weakening" of the thematic field. Such a process of losing perspective might be *synchronic*—when simultaneous features of the surrounding spatial context confuse the evaluation—or *diachronic*—when the evaluator fails to use previously acquired information to respond to a familiar context.[14] Therefore, there are several ways for elements from the margins to penetrate a thematic field and eventually shift its significance. In the radiological context, it is possible to conceptualize such a shift in a few ways:

- The horizon of expectations is too vast. Instead of focusing on one (such as shade or shape), it is as if the *evaluator* takes all the possibilities into *simultaneous consideration*. Several things can appear simultaneously (*fragmented perception*);
- Further mistakes can be provoked when an unusual perceptual strategy and/or attention to strange and irrelevant things occurs;
- The "break down" of a diagnostic process can also show itself as the prolonged concentration on a particular fragment, thus lacking the structural necessity to scan other fragments ("staring"), replacing a thematic object (category) with some fragment (feature), (*selective attention*).

In one way or another, diagnostic mistakes originate in an inability to switch apprehensions:[15]

It is worth noting that the gap between a failure of diagnosis and neurotic disorder is not always so vast because the disintegration of context influenced by marginal experiences can be followed by intense emotional inadequacy, and emotions are also modes of *attentionality*.[16] On the other hand, a radiologist's sensitivity to reasons (not marginal causes, but thematic motivational context), i.e. the capacity to *individuate* relevant objects and the capacity to *discriminate* between relevant and irrelevant relations (categories), actualize the *telos* of her perception—to see appropriate motivational function in the diagnostic object's properties. Many of these dangers concerning the diagnostic process, and even the radiologist's psychic wellbeing, depend not so much on her knowledge as on the way this knowledge is guided (externalized) by the enaction of diagnostic tools.

[14] See, in this regard, Embree 2004.

[15] In order to be able to collect groups together, compare them, and think them together in a single act, which at the same time does not simply merge the two groups, quickly catapults us into the domain of symbolic thought. Husserl's early conclusion was that many concepts require mental acts that are directed upon other mental acts ("Philosophy of Arithmetic", Hua X).

[16] See, in this regard, Leder 1990.

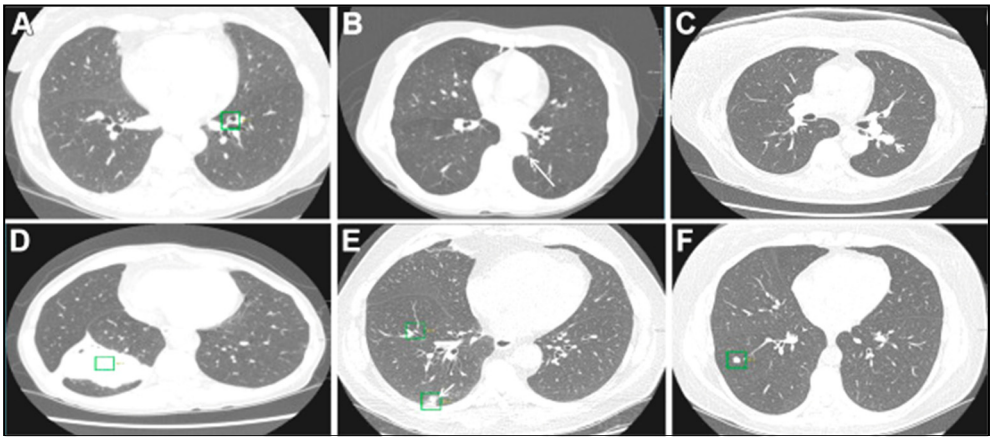


Figure 13. Chest CT.
These are examples of how malignant masses were missed by radiologists because of the unusual location—e.g. close to pleura or bronchos where the radiologist is used to seeing such large structures as organs and eventually misses small ones.

An inability to switch apprehensions may have various causes: inexperience; redundancy; fast pace; strong sense of guidance; satisfaction of search, etc.

2. Animacy Impressions and the Enaction of Radiology Images by Language

In this section I will present the analysis of some language to which radiologists are introduced by learning and use in formal and informal communication, but also during the enaction of images.[17] Of course, the problem of the relation between experience and language permeates all disciplines, and philosophers continue to debate which comes first. On the other hand, common sense would tell us that propositions – for example, diagnostic judgments – come rather late, only *after* some experiential factual data is gathered by the senses of the diagnostic subject. This is problematic though, because, first of all, what I mean by language in diagnostic praxis is not homogenous There are, for example, *causal verbs*, which may need to be enacted and serve as tools to apprehend a certain pathological causality (Wolff 2002). On the other hand, there is also a *narrative moment* in medical diagnostics concerning the general biological and pathological processes. Moreover, I will argue that diagnostic praxis might be just on the verge of something new concerning perceptual and linguistic practices. Now I will examine various ways in which language relates to the diagnostic process:

[17] On the relation between language and enaction see Bottineau 2010.

- The effects of language on experience and attention – for example, via causality, time, etc.;
- Words and linguistic patterns are tools created to cope with and solve diagnostic situations – for example, they found mnemotechnics;
- Narratives provide an additional set of abilities for the professional;
- Intersubjectively established language concerning radiological phenomena normatively situates the diagnostic perception.

Narratives are produced socially in shared practices. They are passed on to novice radiologists early on in their professional life, along with countless images of pathological processes (for example, cancer). Narrative language in cancer diagnostics includes many causal verbs, which connect categorial situations through which the process of disease unfolds as a whole. For example, in descriptions of the nature of cancer, a lot of animated, anthropocentric, and narrative language is deployed:

> Malignant tumors are ambitious. They have two goals in life: to survive and to conquer new territory – metastasizing.
> Metastasis is the process by which a tumor cell leaves the primary tumor, travels to a distant site via the circulatory system, and establishes a secondary tumor (primary tumors somehow keep smaller ones intact, removing primary ones might foster others to grow).
> Cell division, growth and death. Change in the structure of regulation of proteins. Cells respond to the DNA damage via several mechanisms. Translocation, amplification, unregulated cellural growth, loss of heterozygosity, gene silencing, chromosome instability, caretaker genes, suppressor genes, stimulation, invasion, attachment of cells.
> It was suggested to kill the tumors, by starving them of a blood supply. Cancer cells feed and travel via blood vessels.[18]

Examples above show how many causal verbs are used in cancer narratives ("prevent something" would be a causal verb, while "in order to conquer new territories" would be a narrative one).

The use of anthropomorphic expressions (e.g. conquer, fight) amplifies causal impressions of biological processes (pushing, growth, relocating) to the level at which they are transformed into *animacy impressions*.[19] Let me stress

[18] These expressions come from various sources, both written and spoken, published as scientific publications or posted as internet articles.

[19] Animacy: perception of an abstract shape *as* being alive, creating damage, etc. We see inanimate things behaving *as* active, passive, good, bad, aggressors, etc. Animacy brings in a hermeneutic narrative based on bio movement and causal impressions.

that this is not such a unique thing in the scientific world – for example, biochemists reason about the molecular structure by using their bodies to imagine relations between parts of the molecular structure (Myers 2008).[20] Animacy impressions mean that biological or even mechanical processes are endowed with a kind of "primary subjectivity": teleology of being, active interactions with environment, and narrative unfolding – all of which, according to Hans Jonas, may be seen in the process of *metabolism* (Barbaras 2010). Animacy impressions amplify causal impressions, because the experience of primary subjectivity connects various causal events to a greater teleological whole. The impression of animacy adds a qualitative (subjective) dimension to causal impressions, thereby stimulating new diagnostic concepts (or rather intermediary verbs) and connecting causal impressions to narrative language, which is the basis for propositional diagnostic judgments.

Let us further illustrate these ideas by briefly considering the history of medical language. As we know, as one of the great historic professions, medicine has a special relation to ancient languages, such as classical Greek and Latin. I argue that these great traditions appear in contemporary medicine not simply out of respect for tradition, but because they serve as meta-tools for individual radiologists, for example, as mnemonic strategies. For example, lyssencephaly (λισσεγκεφαλία, pr. lissengkephalia), from the classical Greek word lisso (λισσός) meaning smooth and encephalon, a disorder characterized by smoothness (lack of folds and grooves) of the brain, hydrocephalus (υδροκέφαλος, pr. hidrokephalos), from classical Greek word ύδωρ (hydor) meaning water + kephale.

While the name of the pathology sounds sophisticated, it also hides a very complicated net of relations between causal impressions and narrative language. Every such case includes several structural ingredients, namely a name, a thing and/or tool, and a contextual meaning that relates to a Mythic understanding. Now I state that names, things, and tools here already presuppose the knowledge of usage and/or possibilities to move, which rests on causal categorial impressions. So the name of pathology is never neutral; it opens a horizon of teleological coping and within a greater usage setting (Heidegger 1978). It already carries a definite number of movement-usage meanings and possible directions. This is how ancient terms amplify causal impressions in

[20] This can also be turned around and used in learning situations – e.g. getting others to move allows them to see relations. See, in this regard, the paper on enactive metaphors by Gallagher and Lindgren (2015).

image apprehension and constitute animacy impressions.[21] Under animacy impressions, apprehension of causality is modified – for example, the impression of causal relations in pathological process may be understood as based on a differentiation of functional roles (labor, defense, communication, etc.). Mythic understanding as the horizon for such modification amplifies, for the radiologist, basic causal connections in image apprehension, presupposing optimal motor skills. Moreover, it also gives a sense of narrative direction and professional identity (Gallagher 2017a).

Structure of the experience motivated by causal verbs:

Name (classical Greek/Latin)
Thing/location/tool/weapon/building/natural site/element
Causal impressions, affordances for navigation
Animacy impressions (sense of primary subjectivity in pathological processes)
Myth (narrative logic, general sense of right action and justified goal, "because of" motives)

This scheme presents how the network of meaningful connections and impression amplifications constitute a powerful tool for mnemonic strategies, based on:

- Names as commands. The name functions performatively, as a command, and it makes the command clear;
- Nouns as verbs. Deleuze (1990) argues that we need to think of all nouns as verbs, a green thing as a "greening", a tree as a "treeing". The same holds for the term "image"; it is an imaging, and with the content of medical images (see the example concerning pointing to shades above).

Learning the name of something, instead of naming it, is crucial in connecting the radiologist to the already sedimented knowledge of the medical tradition. In this way, medical names and/or nouns connect the radiologist to the dynamics of causal relations and causal impressions, and invites synchronization of movement (coping and searching patterns). Actually, everyday language also tries to convey narrative medical information via names – for example, "measles rush" – but, of course, this is not at the level of understanding causal relations and preparing to follow as in the case of professionals.[22]

[21] Animacy impression is basically the phantasy ("as if") modification of causal impression. As such, it is also a neutralization of a *natural attitude* claim to view such animated processes as having "real" ontic status. Rather, it serves epistemological needs.

[22] "Stroke" is yet another perfect example of language being situated in between everyday and medical worlds.

A (body) scheme (Gallagher 1986) helps not only to understand anatomy and pathology, but also to act in the correct way under certain (categorially-narratively disclosed) circumstances. According to Gallagher, shared experiences open a space in which to act, and narrative provides additional sets of skills (2017a). Therefore, embodied cognition in radiology comes to the radiologist synchronizing causal impressions with affordances opened up by the narrative understanding of an image. Deciphering the meanings of these ancient terms affords a glimpse into not only our medical heritage, but also the intersubjective, historically, and socially sedimented horizon within which individual diagnostic intentions originate. As such, this scheme connects individual perceptions with a general "language game". Let's look at how basic stages of cancer progression are presented in medical discourse, combining causal and animated impressions with narrative logic:

> 1) Immortality: Continuous cell division and limitless replication; 2) Produce 'Go' signals (growth factors from oncogenes); 3) Override 'Stop' signals (anti-growth signals from tumor suppressor genes); 4) Resistance to cell death (apoptosis); 5) Angiogenesis: Induction of new blood vessel growth; 6) Metastasis: Spread to other sites (first four present at cancer progression at the molecular and cellular level but other two are accessible by imaging) (Gutchner and Dietrich 2012).

In classical narrative theory, action begins just when the balance of a normal state or process (for example, mortality) is disturbed (Greimas 1976). It needs a hero (subject, perhaps tumor suppression genes) who emerges and aims to reestablish the status quo. Some of these actions might be attributed to non-human figures, natural forces, etc. Narrative forms of these heroic accomplishments are universal, but their sense is fulfilled only in the concrete act of experience, when self-constitution of the experiential ego occurs alongside place, time, and other relations, and expresses these in terms of *causal verbs*, the latter being verbs that signify motion and other vital information – such as goal-orientation, insistency, and not always involving a change of location (e.g. tremble, shrink, mix, burst, etc.).

Biological interactions as complex objects (causal relations) of medical imaging are such that presuppose the "as if" will to power impressions (animacy impressions). Objects under the radiologist's gaze turn into syntactic agents, which in turn "meet" the (diagnostic) subject. At the same time, the diagnostic gaze is transformed into the pragmatic tool for the subject – he frames, reframes, closes up, distances, differentiates, and modalizes. In this way, the radiologist transforms a complex articulated object disclosed in an imaginative synthesis into a propositional meaning – for example, "it is fortunate that this tumor is benign".

It is possible to look at transformed visual intentionality via notions of narrative cognitivist categories, such as chasing, the urge for joining, domination, etc.

Predictive behavior of bio-organisms sustains narrativity, wherein the radiologist sees them acting according to obstacles and possibilities disclosed by the narrative, and the radiologist is inclined to think that this is the same narrative for everyone. Then the thing retains its identity not so much of itself, but rather because of collective perspectives or other professionals. The sense of a common world then is dependent upon others – physicians who know the narrative and bio-organisms who enliven it. New findings in cancer studies might negate some things or add new ones, but the general structure of collective sustenance of narrativity and the impressions of animacy will remain.

Conclusions

Radiologists' diagnostic environment is affected by various modes of medical imaging and regional knowledge (basic abnormal progressions or categories). This modifies strategies of embodied enactive cognition and presupposes the ability to manipulate several apprehensions based on the same image.

In radiology visual search patterns follow categorial ones which in turn are founded in causal impressions. Radiologist knows (from pathology studies and clinical guidance), for example, structural and process changes concerning *eventration* or *hernia*, that is how after normal state of interrelations is disturbed, the experience of new causal categories appear. Therefore, she relates necessary fragments of an image according to these categories, not the other way around. On the other hand, causal impressions, which found categorial intuition, are produced by the enaction of imaging technology.

The meaning of a diagnostic image also may be constituted by the enaction of an image by language, such that would amplify causal and animacy impressions. This means that there is some embodied intersubjective ground for interpretation and communication of diagnostic images even before the visual search and empirical transmission of information occurs.

The whole body of this research suggests that images and language relevant to radiology should be viewed as diagnostic tools rather than representations.

This research was funded in part by BAFF (Baltic-American Freedom Foundation). I am grateful for their support. The research has also benefitted from the valuable comments and feedback provided by Prof. Shaun Gallagher, Prof. Harris Cohen, Prof. Ion Copoeru and Prof. Rūta Briedienė.

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