Causal concept systems

ANITA NUOPPONEN

1. Introduction

When analysing concepts of a certain field, we encounter often concepts that represent something unwanted, undesirable, e.g. failure situations, product defects, imperfections, errors, diseases, defeat, loss, damages, or natural phenomena. These concepts may be easily overlooked in a systematical analysis especially if there are not enough of them to form a distinguishable generic concept system i.e. a classification of them. It is also difficult to find a location for them in a concept system or an ontology of the field.

This paper focuses on causal concept systems and suggests a model for analysing them. As a point of departure I take my earlier studies on causality and classifications of concept relations and types of relation member concepts (Nuopponen, 1994a, b, c, d). These classifications and concept system models are based on ideas of causation from philosophy (e.g. Aristotle, Hume, Mill, Mackie). Also in this paper I continue this top down approach and discuss the categories from earlier studies. The purpose here is to continue the harmonization of my previous concept analysis models, a project that I have been doing during the last years (see e.g. Nuopponen, 2005, 2006, 2007).

My interest lies in developing the basic theory and methods of terminology science and terminology work as to the concept relations and concept systems. The focus is on the terminological hand-crafting rather than corpus terminology or computer-aided analysis. The results may be, however, utilized and "translated" e.g. by data modellers or ontology building specialists.

2. Concept relations

The latest updated version of my concept relation classification can be found in Appendix 1. The branch of causal concept relations (2.2.1) will be dealt and expanded here. Several other types of relations in the classification are closely related to causal relations and include causal elements, but they are kept separate even though they are sometimes regarded as causal for instance by certain philosophers. Especially activity and origination relations belong to these. Activity relations are based on a connection between an activity concept and phenomena involved in the activity (*agent, object/patient, tool,*

location, purpose) (see more in Nuopponen, 2006). Origination relations exist between a concept that refers to a concrete or abstract entity and concepts that refer to the origin of the object (e.g. *original material, producer, instrument, manufacturing method, manufacturing process, place of origin, purpose,* etc.).

3. Causal concept relations

A causal concept system comprises of relations which obtain primarily between the cause concept and the effect concept. In addition, there are several other concept relations involved. It is, however, this basic relation that for instance ISO 1087 standard mentions. It defines causal relation as associative relation "involving cause and its effect". If we look at a cause and its effect closer, we will find more relation types and whole chains of causal concepts.

Before discussing further details, discrimination is needed between the different levels we are dealing here with: **ontical level** (i.e. level of physical or factual existence) and the **conceptual level**. Causal concept relations are formed on the basis on observations of the causal connections between entities on the ontical level. Concepts in a causal concept system refer to various "participants" in the actual causal event or chain. Furthermore, designation level (term level) could be added. This paper focuses, however, only on ontical and conceptual levels. The designation level has been, however, valuable to locate the concepts and relations between them when descriptions of causal phenomena (e.g. *common cold, diving hazards, global warming*), were studied in order to test the ideas presented here.

Appendix 2 presents the modified typology of causal relations to be discussed here. I distinguish between sequential causal relations and causal coordination. For instance, both causes and effects can appear also simultaneously or alternatively, why the corresponding concepts are treated here as causally co-ordinate concepts in a causal concept system. In the following, the member concepts (referring to cause, effect, symptom, consequence, patient and counteracting cause) in causal relations are discussed separately before combining them into a causal concept system.

3.1 Causes

I divide causes into causal agents, producing causes and explanatory causes. A **causal agent** is a person or phenomenon which can be considered to have caused something (e.g. *rhinovirus* -> *common cold*). A **producing cause** is an action or event which has contributed to something which has happened (e.g. *smoking* -> *cancer*; *earthquake* -> *tsunami*). An **explanatory cause** is state, condition or property of things, which has contributed to something

which has happened (e.g. *to be allergic -> allergic reaction*, *inflammability -> fire*). The corresponding cause-effect relations could be called 'causator relation', 'causation relation' and 'circumstantial relation'. All of them have two subtypes depending on from which direction we are looking at the concept relation. Concepts referring to alternative causes have **causal disjunction** relation between them while the relation between concepts referring to different causes needed to bring about the effect can be characterised as **cause conjunction** (co-occurring causes).

3.2 Effects

ISO 1087 exemplifies causal relation with *action -> reaction*, and *nuclear explosion -> fall-out*. The first one refers to the relation between an event as a cause (producing cause) and an event as the effect (here: **resulting event**); in the second example the relation is between an event and a substance as the effect (here: **resulting product**). In addition to resulting event and resulting product, an effect can be **resulting state** (Nuopponen 1994b; 1994c).

A producing cause or a causal agent may bring about an event (*earthquake -> flooding; pollutant -> pollution*), a product (*earthquake -> seismic wave*; *exposure to ultraviolet radiation -> sun tan*) or a state (*earthquake -> property damage*, *overeating -> obesity*) as an effect. Also explanatory causes may bring about resulting event (*humidity -> sweating*), resulting product (*humidity -> sweat*) or resulting state (*humidity -> hyperpyrexia*) in conjunction with another type of causes.

		causes		
		producing cause	*causal agent*	*explanatory cause*
effects	*resulting event*	causation relation	causator relation	circumstantial relation
	resulting product	causation relation	causator relation	circumstantial relation
	resulting state	causation relation	causator relation	circumstantial relation

Table 1 Cause-effect relations

In Table 1, I have named the cause-effect relations according to the type of cause. It is possible to differentiate between these relation types also terminologically, if necessary (cf. Appendix 2). Furthermore, the direction of the relations between the concepts may become important in certain contexts. Effects can appear also simultaneously or alternatively, why the corresponding

concepts are treated here as causally co-ordinate concepts in a causal concept system (effect conjunction; effect disjunction).

3.3 Symptoms

Symptoms are closely connected to effects. They are called 'symptoms', 'signs', 'signals', or 'marks' in different fields. Symptoms could be regarded as effects, but on the other hand they belong to the resulting event (*earthquake - trembling*; *dehydration - weight loss*), resulting product, or resulting state (*pregnancy - morning sickness; humidity - water vapor*) itself as its characteristics or constituent parts. The effect (e.g. *allergic reaction*) does not cause a symptom (e.g. *itching*), but instead the symptoms reveal the effect caused by something else (e.g. *dust*). The relation between e.g. an illness concept and a symptom concept could be sometimes classified as a partitive concept relation, property relation, or even representational relation (see 2.1.1, 2.1.5, 2.2.4.4 in the Appendix 1) depending on the case. If it is necessary to emphasize the causal nature of the relationship, the relation between the effect concept (event, product or state) and the symptom concept could be called 'symptom relation'.

The symptoms can be on the one hand co-occurring (**symptom conjunction**), alternative (**symptom disjunction**) or occasional and on the other hand primary or secondary symptoms. Sometimes there are lengthy lists of symptoms, e.g. the symptoms of illnesses, signals of changes in the economical or political climate, etc. Furthermore, each of the signals or symbols may have their own causes which are subordinated to the overall cause.

3.4 Consequences

Consequences and complications could be distinguished from effects and their symptoms in some cases. They are regarded here as something that may follow from an earlier sequence in a causal chain. For instance, the actual causal chain from earthquake to public health consequences is longer than that including causal events which especially contribute to this type of consequences. The consequences or complications may or may not appear depending on many factors, for instance *common cold - sinusitis*. Consequences may be co-occurring or alternative, too. Cause-consequence relation requires further examination with empirical material. Same goes for finding out if it is necessary to distinguish between consequence concepts and complication concepts in a causal concept system.

3.5 Patients

Causal concept systems involve also a concept or a set of concepts referring to a "patient" ("one who endures/suffers"). Patient is a concrete or an abstract object which is affected by the cause and in which the effects and their symptoms appear. For instance, the patient of common cold is human being, and the patient of a flood is land area etc. Several relation types can be distinguished: cause-patient and effect-patient, where both cause and effect has different forms (see Appendix 2). Furthermore, each symptom may appear in different part of the main patient, e.g. the symptoms of common cold appear in nose, ears, sinuses etc. This involves partitive or locative concept relations, when we define which part of the patient is affected by which cause and symptom. There may be alternative patients, or patients that are all are affected simultaneously. Also consequences have their patients. Alone patient-related relationships lead to a large number of concept relations.

3.6 Counteracting causes

In addition to causes, effects, symptoms, consequences and patients, there appear yet an element which cannot be avoided when analysing causal phenomena: factors that counteract the causation process (**counteracting causes**). Counteracting causes may be different types of actors, actions/activities, events, measures, instruments, methods, materials, substances, circumstances etc. They are either intended or unintended (e.g. *smoking - package warning*; *forest fire - rain*), the last one including e.g. natural phenomena that prevent something happening or cause it to stop.

Counteracting causes may try to prevent the effects of a cause, e.g. banning smoking is used to prevent causes of smoking. If the effect is already there, e.g. a person has contracted a disease, medication and other measures are taken to cure it. The symptoms need to be taken care of and consequences are fought with appropriate means. Counteracting causes may also be different in each of these cases as to the patient and part of it. Concepts that refer to intentional measures to avoid something may also be analysed with activity relations (see Nuopponen 2006). An activity has someone who performs it and there is a reason, tools, methods, place, object etc. for it.

4. A model for analysing causal concept systems

When analysing concepts I have been illustrating almost all types of concept systems with a mind map resembling satellite system model. So far, the causal concept systems have been somewhat problematic. The model is basically hierarchical since it is based on the basic idea is that there is only one

central node and each node may have only one upper node. However, the same concept may be inserted in as many subnodes as needed. Concepts involved in causation form rather a network or a flowchart than a hierarchy and have several points of departure. Despite this I find satellite model a useful and illustrative way to map concepts and I have solved the problems by interconnecting several separate satellite models with the help of the overlapping concepts. Any of the elements, may be taken as a point of departure in a model of its own, see Figures 1 and 2 where cause and effect have been selected as the center nodes.

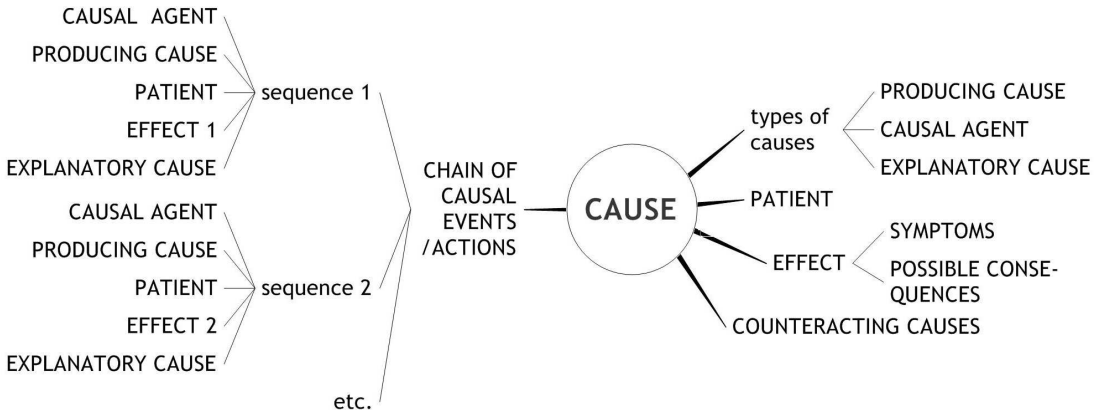

Figure 1. Cause as the central node

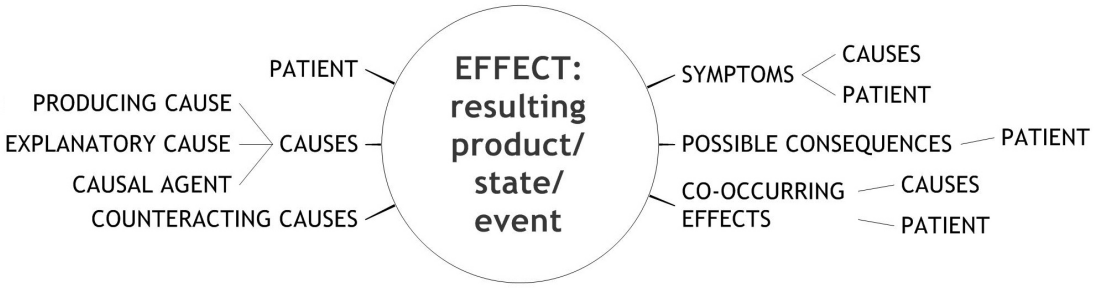

Figure 2. Effect as the central node

When analysing a set of concepts related with different types of causal relations, there is, after all, often a certain point of view or point of departure that is emphasised. In Figure 3, the central node is *common cold*, i.e. a concept referring to an effect, and all the other components are primarily related to it. Instead of separate types of relation markers, I have been using relation members as connecting nodes. Instead, the name of the relation type could be written in the node, but not all of them are named yet. Furthermore, the relation designations are not always easy to remember.

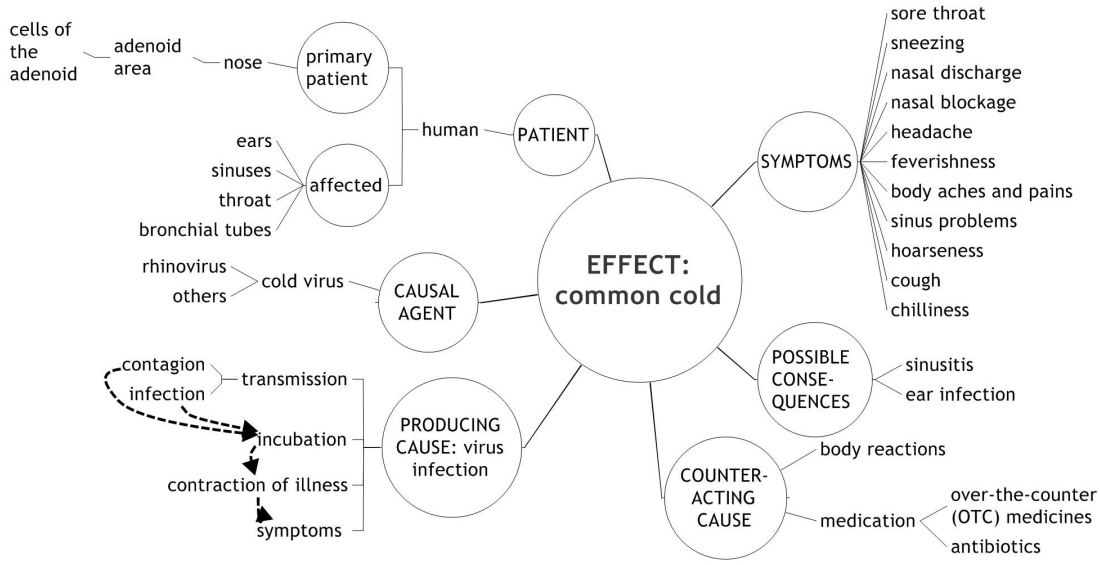

Figure 3 Concept system of common cold

The effect is the point of departure often when describing causal phenomena such as illnesses, e.g. common cold, pneumonia, or natural catastrophes, e.g. tsunami, earth quake. Another example is squeeze which is especially a scuba diving related pain occurring mainly in the ear caused by the pressure difference between the middle ear and the outside environment. There are however several different types of squeeze: lung, ear, sinus, tooth and gut squeeze, eye squeeze as well as squeeze caused by the mask or dry suit. All of these need their own further analysis. Both Figure 3 and 4 show only a very general idea of the concept systems, and in order to extend them to the specialist level, each of the main nodes should be taken separately as center nodes to be analysed in more detail.

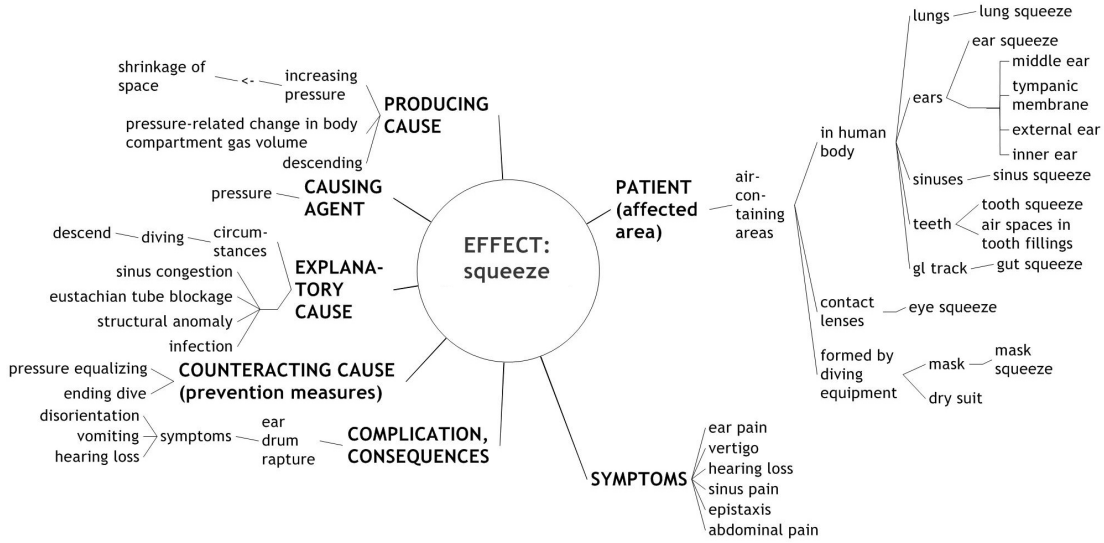

Figure 4 Concept system of squeeze

Both examples had the effect concept as the central one, some other cases it is however the cause that is selected as the point of departure, e.g. when discussing effects of smoking, TV watching, education etc. Also the other causal elements may appear as central nodes, e.g. the patient in the case of pets and their illnesses or products and their defects. If the task is to produce e.g. on the macro concept system covering all the concepts of the field, whole causal concept systems or fragments of them can be integrated into it via overlapping concepts.

5. Conclusion

Causal concept systems are an interesting but maybe the most difficult system type to be modeled. The model suggested here builds on a mind map like satellite system model, which takes one element at time as the point of departure and combines the other elements in satellites around the core concept. Several types of causal concept relations were discussed and compiled as a classification in Appendix 2. So far I have been developing these methods from the point of view of a human analyser instead of taking into consideration databases and other terminological tools and their needs, limitations or possibilities. I hope, however, that the top-down classification presented here may be helpful for e.g. those who are work with corpora and linguistic forms and create the relation classifications with bottom-up approach.

I have discussed here some of the main elements in causal concept systems, but there are still several open questions. So far I have used more or less popularised texts from diverse Internet sources when testing and exemplifying the ideas. As soon as one starts to analyse more scientific texts e.g. on diseases, causal concept systems become even more detailed and complicated.

Furthermore, I have now talked about causes and their effects as negative phenomena, but the positive causes and effects should not be forgotten. For instance, we may analyse the reasons for a good result or a victory and their consequences. Counteracting causes would then be negative phenomena that try to prevent the success. Here I would like to quote a student of mine who was analysing literature concepts and as an example of causal concept systems compiled a presentation, where the central question was: why does a novel become a bestseller and what does follow from it. Another causal system she built focused the concept *writer's block*. This made me finally convinced that causality can be found everywhere and causal relations are useful as concept analysis tools.

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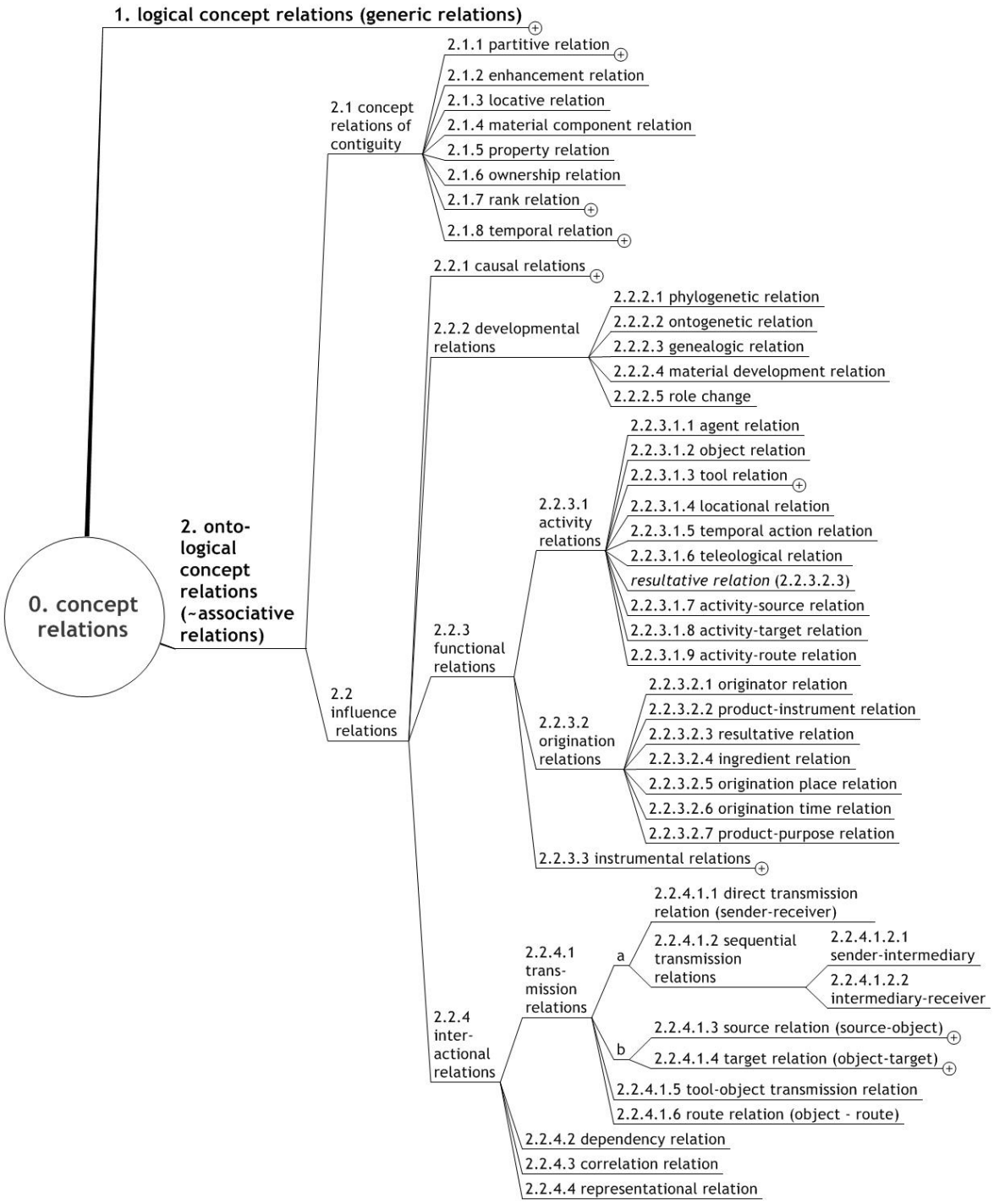
Appendix 1. Concept relations



Appendix 2. Causal concept relations