The relation between cognitive and linguistic structures

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Abstract

While there is large agreement that there must be a systematic relation between the cognition of single individuals and the public meaning of lingusitic expressions, there is no theory that could describe this relation systematically and formally. The aim of this paper is to describe a framework that is able to fill this gap. We will use frames as an adequate format to describe both mental representations and linguistic meaning. The central thesis is that the rich structures of individuals' representations overlap in the sense that they share a common core. This core can be identified as the public meaning of the word associated with these mental representations (concepts). Both levels are systematically related by abstraction mechanisms (from cognition to language) and attunement mechanisms (from language to cognition).

Keywords: concepts; frames; meaning; mental representation; natural language; communication

Linguistic Meaning and Individuals' Cognition

One of the most central questions in the philosophy of language is the metaphysical question what meaning is and how it is constituted (or, to use the title of a seminal paper by Putnam, what the "meaning of 'meaning"' is; Putnam 1975). The most influential (and traditional) view is that meanings are some kind of objective, abstract entities or relations which are shared or commonly accessed by speakers of a language community (see, e.g., the classical arguments in Frege 1892). However, language users need some "grasp" or representation of such meanings in order to communicate. Although it is widely agreed that the relation between the individual level of representing entities (objects, situations, etc.) and the public level of linguistic meaning has to be described in detail, it has mainly been described as a problem: For example, in the Fregean tradition the question is what it is to grasp a meaning (a "thought" or a "sense" in the Fregean terminology), i.e. how the abstract meanings are reflected in individual representations of entities. In the (later) Wittgensteinian tradition of use-based theories, the question arises how it is possible to learn the public meaning on the basis of individually different sets of uses one is acquainted with. In recent "cognitive semantic" theories, which take public meanings to be strongly based in individual cognition, the problem is to explain the emergence of linguistic meanings from disparate and maybe inhomogeneous individual meaning representations.

The most influential framework to address such questions is probably the so-called "Gricean Program"[1] (cf. Grice, 1957). It postulates five levels which need to be ultimately accounted for by a comprehensive theory of linguistic meaning:

(5) recursive semantics for the object language L

(4) theory of intersubjective, conventional meaning of utterances (what is said)

(3) theory of subjective meaning of utterances (what is meant / what is understood)

(2) psychological theory of the mental states (propositional attitudes) of the users of L

(1) description of the observable behavior of the users of L.

Although serious doubts have been raised against the details of the program (e.g. against the possibility of describing propositional attitudes independent of conventional meaning; see Burge 1979), the overall rationale of the framework is still widely accepted (for a cognitive expansion of the general framework see Sperber and Wilson 1986). However, one of the general problems is relating the intersubjective meaning (henceforth the public meaning) on level (4) to the content of individual mental representations on level (2). Although level (3) might in principle seem to provide a link, the usual description of this level in the Gricean tradition is, first, concerned with a rather inter-subjective level of communication, which is not thoroughly linked to a truly subjective level of representing entities, and is, second, restricted to the meaning of utterances of whole sentences. This paper, however, is mainly focusing on the meaning of smaller units such as phrases and words on the linguistic level and concepts on the mental level, for which the link between public meaning and individual mental representations has rarely been systematically discussed. Thus, although the paper follows the general idea of the Gricean program, it will not assume that the relation between public meaning and individual mental representations has to be described as a three-step relation in the way Grice describes it.

In order to develop such a systematic account of the relation, we need three things: First, we need a detailed and

[1] The "Gricean Program" as such does not contain the Gricean theory of implicatures; rather, the latter is Grice's own way of carrying out the program, which can also be carried out in many non-Gricean ways.

adequate format of describing individuals' mental representations that is rich enough to account for the individual differences. Second, we need a detailed and adequate format for describing the public meaning of linguistic expressions. Third, we need a systematic link between the two descriptions, one which explains how public meanings "emerge" from mental representations of multiple individuals, i.e. that explains how public meaning is "grounded" in mental representations.

This paper aims at sketching a first frame-work for such a systematic description of the relation between public meaning and individuals' mental representations. It assumes that frames constitute a suitable format of describing both mental representations and public meaning. If, as assumed here, both levels can be described with the same format, the relation between the two can be described as a relation between structures in the same format, which renders the whole enterprise feasible. We will now introduce frames as a format of describing mental representations, especially mental representations of classes of entities (concepts[2]). We will then explicate the central thesis that public meaning is the overlap between the structures of the mental representations of different language users, before we will discuss mechanisms of abstraction, which lead from individuals' mental representations to public meaning, and mechanisms of attunement, which describe the influence of public meaning on individuals' mental representations.

Frames as Structures of Concepts

Barsalou (1992) proposes that concepts can be naturally described in terms of frames. Frames as recursive attribute-value structures have been widely used as a general format for knowledge representation, e.g. for capturing linguistic knowledge (Fillmore, 1970) or situational knowledge (Minsky, 1975). Advancing the basic ideas of Minsky (1975), Barsalou (1992, p. 21) argues for frames as "dynamic relational structures whose form is flexible and context dependent". He presents psychological evidence for attribute-value structures derived from behavioral animal studies. These studies indicate that animals encode stimulus information as attribute values and not as independent features. Furthermore, he gives empirical evidence for the importance of conceptual relations in human cognition. Here, we will briefly sketch our frame account which builds on Barsalou's flexible cognitive approach, but provides it with a rigid formal foundation (see also Vosgerau, Seuchter, & Petersen, in press).

The attributes in a concept frame are the general properties or aspects by which the respective concept is described (e.g., SHAPE, LOCATION).[3] Their values are concrete or underspecified specifications (e.g., [SHAPE: *round*], [LOCATION: *forest*]). The attribute values can themselves be complex frames and thus described by additional attributes. E.g., the value *forest* of the attribute LOCATION can be further specified by attributes like SIZE or TREE SPECIES. Due to their recursivity, frames are flexible enough to represent information of any desired grade of detail. We assume that attributes in frames assign unique values to objects and thus describe functional relations. Formally, frames can be represented by connected directed graphs where the arcs correspond to attributes. As attributes are functions, no node may have two equally labeled outgoing arcs. The nodes may be labeled by types which restrict the attribute domains and ranges, i.e. the set of objects for which an attribute is adequate and the set of values an attribute can take.

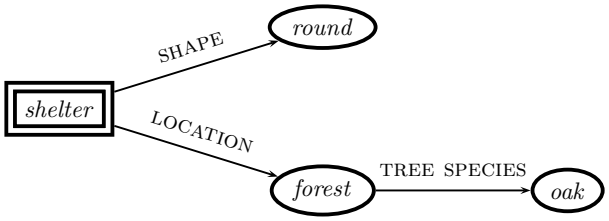

Figure 1: Frame of the concept 'round shelter in oak forest'

Figure 1 shows two additional notational devices which we use in our graph representations of frames: First, the double border at the *shelter* node marks it as the central node of the frame; it indicates that the graph represents a frame about shelters. Second, by using a rectangular node for the central *shelter* node, we identify the whole frame as a concept or category frame which corresponds to a 1-place predicate the argument of which is represented by the shelter node. A round central node would indicate instead that it is a frame of a not further specified category member of the category 'round shelter in an oak forest'.

In contrast to other frame theories, our frames are capable of representing not only sortal concepts like SHELTER, which denote classical categories, but also relational ones like SIBLING or MOTHER (Petersen, 2007); the referents of the latter concepts are given by a relation to a possessor ("sibling of", "mother of"). Frames of relational concepts differ from frames of sortal concepts in that they have an additional rectangular node for the possessor argument. Figure 2 shows the frame for the sibling concept. It consists of three nodes, one for the sibling itself (rectangular, double border), one for the person it is the sibling of (rectangular, single border) and one for the mother of both (round). The relation between the two persons is constituted by the fact that they both have the same mother.[4] This is modeled by the single node to which the two MOTHER-arcs point. Note that in contrast to classical frame accounts our approach does not presuppose that the central node of a frame, i.e. the node which determines what is de-

[2]Throughout the paper, the term "concept" will be used for mental representations and not for linguistic expressions.

[3]Throughout this paper attributes are typeset in capitals and their values in italics, while concepts are set in small caps.

[4]Note that all frames in this paper are severely simplified. The frame in figure 2 e.g. models the sibling concept as being purely determined by the mother relation, leaving aside fathers or socially established family relations.

noted by a frame, is a root node of the frame graph.[5]

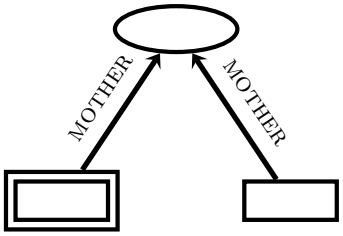

Figure 2: Frame for the concept 'sibling'

An adequate frame theory needs means of restricting the set of admissible frames. Therefore, frame nodes may be labeled by types. The types are ordered in a type hierarchy which is enriched by appropriateness conditions which constrain the domain and range of attributes. Thus the type signature tells which type of entities can have a certain attribute and of which type the values of each attribute are. So, we can infer from an attribute the type of the nodes its arc connects, unless it is further restricted by other constraints in a particular frame. For example, the type signature specifies that the domain of the attribute MOTHER is *person* and that its range is *woman*. In contrast to figure 2, figure 1 shows an example of a frame in which the type labels at the nodes effectively restrict the attribute domains and ranges. E.g., LOCATION is a very general attribute which applies to all kind of physical objects (not only to shelters) and which takes all kind of locations as values (not only forests). The formal details of our frame account can be found in Petersen (2007) and Petersen and Osswald (2014).

Although it is in principal possible to express the informational content of a frame in classical logical formulas, it is more natural to assume that concepts are mentally stored in terms of frames than in terms of formulas. As Barsalou (1992) points out, there is empirical evidence for attribute-value sets and relations in cognition. In frames, concepts remain units although they may be highly structured. This unity is concealed in logical formulas by multiple occurring variables. Furthermore, as predicates are constants in predicate logic, one is forced in a formula representation to stipulate a fixed arity and a fixed order of arguments for each relation expressed by a predicate. Here, frame theory is more flexible: As relations are decomposed into functions with relational arguments, one gains a parameterized access to relational arguments. Thus frames have a non-linear structure in which substructures can be addressed via labeled symbols instead of ordered argument positions which is cognitively more adequate a description of mental representations.

Although some critics have tried to eliminate the notion of representation (e.g. Brooks 1991,Thelen 1995; for a discussion, see van Gelder 1998), a liberal notion of representation has been developed and fruitfully used to philosophically describe and explain various mental abilities in a way that conforms to the experimental research in psychology and related disciplines (cf. Vosgerau, 2009, 2011).[6] In particular, we have developed a cognitive theory of thoughts formulated within a representational framework (Vosgerau & Synofzik, 2010) and shown that our notion of representation is able to integrate ideas of "grounding" and "embodiment" (Seuchter & Vosgerau, 2011; Weber & Vosgerau, 2011, 2012), which are sometimes taken to speak against representations. By using oscillatory neural networks as a biologically motivated model, Petersen and Werning (2007) give evidence for the cognitive adequacy of our frame model and shows how frames might be implemented in the cortex.

In particular, frames are flexible enough to describe concepts that do not reduce to definitions or feature lists, which are central to the "classical" theory of concepts (e.g. Katz, 1999). That is because it is possible to introduce constraints into frames that relate, for example, certain attributes to possible values of other attributes or that determine the presence of a certain attribute given a certain value. Additionally, frames seem to be suited to incorporate statistical information on attributes and values, which allows adopting specific advantages of prototype theory, namely their description of vague concepts. With statistical information and constraints, the information, e.g., that the typical shape of a tree depends on whether the tree has leaves or needles can be incorporated, which is not (straightforwardly) possible neither in the classical theory nor in prototype theory. All of these features are pivotal for describing the diverseness of individuals' concepts: If a concept would be described in a definition-like way, e.g., there would be only one "correct" way of representing it. In this case, language users would either possess the concept or not, and successful communication between a concept-possessor and a non-possessor could hardly be explained. Moreover, the different uses of a word a single individual is acquainted with could be reflected in different statistical information in the two individuals' frames for one concept.

To give a short example: A child, a car mechanic, and a hunter might have very different concepts of cars. While the child can be expected to have a quite limited representation of technical details, the car mechanic will probably have much more "technical attributes" (such as VALVES as an attribute of the engine) in her frame. The hunter, in contrast, may represent attributes related to cross-country mobility in his car-frame. In this way, frames can be used to capture the individuals' differences in concept representations. However, since frames are structures, there might still be a "core" of each individuals' frame that is also present in the others'. In the car-example, this core might contain attributes such as COLOR, WHEELS, ENGINE, FUEL.

[5] A root of a directed graph is a node from which all other nodes can be reached via paths of directed arcs.

[6] The liberal notion defines mental representations as internal states that stand for something else without presupposing that they are symbolic, conceptual, comprehensive, or amodal. Since the critique of representations attack one or more of the additional specifications, the liberal notion is not affected by this critique.

Overlap Between Frames as Meaning

The central thesis of this paper is that the public meaning of linguistic expressions can be understood as the "overlap" between the rich structures of individuals' concepts. Frames provide a promising tool to accomplish this task: Due to their recursive structure, the same semantic unit can be described using very different degrees of granularity, depending on how much of the values are further specified by attribute-value pairs. This allows the identification of a core structure, which is common to all different fine-grained representations of different individuals (the "overlap"). The core structure can then be conceived of as the abstraction of the individuals' representations, which constitutes a distinct level of description, the level of public meanings.[7] We will now spell out this central idea in more detail and identify open questions for further elaboration.

The overlap between the structure of individual representations can be conceived of the result of the generalization operation on frames (Carpenter, 1992). On the one hand, the computational complexity can be expected to be comparatively low given that for a specific concept or word the central node is given; on the other hand, the operation has to be adapted to handle statistical information and constraints (e.g. by computing mean values). However, more pressing is the question whether such overlaps can be assumed at all, i.e. the question if public meanings do exist. For if there is no such overlap, communication cannot be successful. First, it should be noted that there is no strict boundary between successful communication and non-successful communication, as is also reflected by the notorious difficulties to distinguish between different languages, dialects, sociolects, technical languages, etc. (cf. Ethnologue, 2014). In fact, we propose that language communities are constituted by the overlap. Take, e.g., youth "language": whether a given word (e.g. the German adjective "porno") is part of youth language is determined by the degree of overlap between young people's mental representations associated with the word and the non-overlap with the not-so-young people's representations. Thus, language communities are not given independent of overlaps. (Of course, if one speaker does not know a word and thus has no mental representation associated with it, there can be no overlap; this is most obvious for completely different languages.) Second, it can be assumed that there are different mechanisms that contribute to the establishment of overlaps: for basic perception-based concepts, the mere similarity of the perceptual and cognitive apparatuses in different individuals assures a considerable overlap (basic object categorization seems even to be independent of the first language of a person; cf. Malt, Sloman, and Gennari 2003). For more complex or abstract concepts, it is likely that different mechanisms of attunement within language communities are at work so that the common use of language also shapes the concepts (for a review of literature showing the impact of language use on concept acquisition, cf. Rakoczy 2010, sec. 4); these mechanisms include explicit explanations, extra-linguistic reference fixing (e.g. through ostention), and implicit alignment through contextual disambiguation, also involving the "common ground". We will come back to possible attunement mechanisms after describing the counteracting mechanisms of abstraction and enrichment that are at work in concept acquisition, language learning, and language use.

[7] Metaphysically speaking, meanings are thus abstract entities, namely certain structures. Mental representations can have a the same structure as linguistic expressions; in such a case, the content of the mental representation will be identical to the public meaning of the linguistic expression. Of course, mental representations and linguistic expressions have differen "realizations" or "vehicles" and are thus never identical.

Abstraction and Enrichment

In general, abstraction mechanisms lead from specific representations to more general representations, i.e. to concepts. Such mechanisms mark the relation between instantiated frames (standing for particular objects or situations) and general frames (standing for types of objects or situations). Enrichment mechanisms are counteracting abstraction and lead from general frames to instantiated frames. Such mechanisms are employed if a particular entity is subsumed under a concept, i.e. in categorization: If, for example, an entity is categorized as a car, the general car-frame is enriched by specific attributes and values (e.g. the value *red* for the color of the car, or the attribute SPOILER) to represent the specific features of this particular car. Since enrichment mechanisms can be expected to be, in general, just the converse of the according abstraction mechanisms, we will now concentrate on abstraction.

One simple abstraction mechanism eliminates specific values from frames. To take the same example: If a child encounters different cars, she will be able to abstract from the different colors of cars by eliminating the value of the color-attribute. In this way, the general representation still contains the information that each car has some color. A related mechanism will assign statistical information to different possible values. Such a mechanism would result in general frames representing prototype-concepts in the sense of Osherson and Smith (1981). A further abstraction mechanism will eliminate whole attributes that are specific for only some exemplars of a category. For example, the attribute SPOILER is not adequate for every car but only for some. Thus, if a child sees the first car without a spoiler (after having been exposed to different cars with spoilers), she can abstract from this feature by eliminating the attribute SPOILER in her general car-frame (her concept). Such simple abstractions can be formalized by generalizations over all representations of particulars belonging to one category.

However, the most interesting and probably the most important abstraction mechanism is the one that introduces new attributes. Let us illustrate the basic idea with the example of the mother-concept of a child. A young child will acquire a concept of his mother only, i.e. he will not (yet) understand that other people also have a mother. It is likely that the child does not explicitly represent himself as a constituent of the

mother frame; on the contrary, his mother-frame will only be implicitly relate to himself (cf. Seuchter & Vosgerau, 2011). This means that initially, the mother-frame will not contain a mother-attribute mapping from the children of the mother to the mother. Only later, when the child learns that other children have different mothers, the child will add this attribute to his mother-frame and so gains the power of representing different people as the (different) mothers of different children. This abstraction mechanism is likely to play a major role also in adult learning, especially in scientific learning: Often enough, scientific progress is made by introducing more attributes that lead to more abstract, i.e. more general theories. For example, the identification of light and X-rays with electromagnetic waves was only possible by adding the attributes of electric energy, frequency and wave-length to the according concepts.

Abstraction and enrichment mechanisms relate the different levels of frames with each other. Both on the cognitive and the linguistic level, we find instantiated and general frames (see also table 1). All four levels play a crucial role

Table 1: Four levels of frames.

	instantiated	general
individual speakers' representation	mental representation of particulars	concepts (mental representation of types)
public meaning	utterance meaning (in specific context)	semantic meaning (context-independent meaning)

in understanding the relation between individual psychology and public meaning and their interaction in communication: Individuals have representations of concrete particulars with a rich structure of attributes and values. By abstraction, they also form general representations (concepts) of types of entities. Once they are acquired, they can, in turn, be used to represent particulars, in which case context-specific attributes and values are again added to the representation ("enrichment"). Linguistic expressions (words) are associated with the concepts and can be used to communicate about specific things in specific contexts.[8] The utterance-meanings of such expressions used in specific contexts can be described as the overlap between the structures of the individuals' instantiated frames. Abstracting from the specific context will result in the semantic meaning of a linguistic expression, which can be described as the overlap between the structures of individuals' concepts in a given language community.

[8]While full competent speakers mostly have knowledge about the public core, i.e. the semantic meaning of a word, and often enough even have specific knowledge about the specific concept of the person they talk to, both kinds of knowledge are not necessary (although very helpful) for communication and are likely not to be present in young children who are nevertheless competent communicators.

Attunement

So far, abstraction mechanisms lead us from individual cognition to public meaning. However, obviously the use of a common language also has a huge influence on the way we represent things, especially on our conceptual systems. Thus, the framework has to be complemented with mechanisms that describe the influence of language use on individuals' concepts. We will call these mechanisms "attunement mechanisms". The basic idea is that the overlap between the different individuals' frames is increased by attunenment mechanisms. The advantage of our framework is that such mechanisms can be described in detail, such that this description can also serve as a basis for empirical work. So far (to our knowledge), such mechanisms have not been described in detail (at least not in any technical detail), such that most work is still to be done. However, we will now sketch some possible attunement mechanisms to illustrate the general idea and to prove the feasibility of our framework.

One class of attunement mechanisms can be described as *implicit*, since they do not involve communication about the meaning of words. One such mechanism is the use of pointing gestures along with words. In this way, another speaker learns about the extension of the partner's concept (e.g. the concept RED) associated with the word and can attune her own concept. Another implicit mechanism involves the context and the common ground that helps to clarify what is referred to. One concrete example: If we are going outside and you utter "This drizzle is annoying" while opening your umbrella, I will probably understand that you are talking about the rain even if I don't know the word "drizzle". Both attunement mechanisms mentioned help to fix the referent (the central node), such that the hearer can use the abstraction mechanisms to attune his or her concepts with the speaker's concepts. However, there are also implicit attunement mechanisms which do not work through fixing the referent. For example, if I hear someone say "I don't like boarhounds, I prefer long fur", I can learn that boarhounds have short fur.

The other class of attunement mechanisms contains *explicit* mechanisms that involve a kind of "meta-communication" about word-meanings. For example, a speaker might give an explicit definition of a term she uses or paraphrase it. But meanings can also be bargained about in a communication, if the communicators have different ideas (e.g. whether this shade of green qualifies as teal). Moreover, people can refer to expert-knowledge, as in "Philosophers understand this term as referring to ...". Obviously, explicit attunement mechanisms aim at creating a more consistent use of words between individuals, which is described as an increase in concept-overlap according to our framework.

Conclusion

Frames are rich enough to provide a detailed and adequate description of individuals' mental representation, in particular the representation of concepts. Due to their recursive structure, they are apt to describe concepts at different levels

of granularity. Therefore, they are also apt for describing the public meaning of linguistic expressions. Thus, a systematic explanation of the relation between cognitive structures and linguistic meaning becomes possible. We elaborated on the thesis that public meaning can be understood as the overlap between the individuals' frames for concrete particulars and for classes of entities. According to our framework, the level of public meaning is grounded in the cognitive level by abstraction mechanisms, while it has a huge influence on the cognitive level through attunement mechanisms. In this paper, we could only describe a general framework which leaves much detail work for the future, especially regarding the formal description of attunement mechanisms.

References

Barsalou, L. W. (1992). Frames, concepts, and conceptual fields. In A. Lehrer & E. F. Kittay (Eds.), *Frames, fields, and contrasts: New essays in semantic and lexical organization* (pp. 21–74). Hillsdale: Lawrence Erlbaum Associates.

Brooks, R. A. (1991). New approaches to robotics. *Science*, *253*(5025), 1227–1232.

Burge, T. (1979). Individualism and the mental. *Midwest Studies in Philosophy*, *4*(1), 73–121.

Carpenter, B. (1992). *The logic of typed feature structures: With applications to uunification grammars, logic programs, and constraint resolution* (Vol. 32). Cambridge and New York: Cambridge University Press.

Ethnologue. (2014). *The problem of language identification.* (http://www.ethnologue.com/about/problem-language-identification; last access: 2015/3/1)

Fillmore, C. J. (1970). The case for case. In E. Bach & R. T. Harms (Eds.), *Universals in linguistic theory* (p. 1-88). London, New York, Sydney, Toronto: Holt, Rinehart and Winston, Inc.

Frege, G. (1892). Über Sinn und Bedeutung. *Zeitschrift für Philosophie und philosophische Kritik*, *100*, 25–50.

Grice, H. P. (1957). Meaning. *The Philosophical Review*, *66*(3), 377.

Katz, J. (1999). On the general character of semantic theory. In E. Margolis & S. Laurence (Eds.), *Concepts: Core readings* (pp. 125–150). Cambridge and Mass: MIT Press.

Malt, B. C., Sloman, S. A., & Gennari, S. (2003). Speaking vs. thinking about objects and actions. In D. Gentner & S. Goldin-Meadow (Eds.), *Language in mind* (pp. 81–111). Cambridge and Mass: MIT Press.

Minsky, M. (1975). A framework for representing knowledge. In P. Winston (Ed.), *The psychology of computer vision.* New York: McGraw-Hill.

Osherson, D. N., & Smith, E. E. (1981). On the adequacy of prototype theory as a theory of concepts. *Cognition*, *9*(1), 35–58.

Petersen, W. (2007). Representation of concepts as frames. *The Baltic International Yearbook of Cognition, Logic and Communication*, *2*, 151-170.

Petersen, W., & Osswald, T. (2014). Concept composition in frames: Focusing on genitive constructions. In T. Gamerschlag, D. Gerland, R. Osswald, & W. Petersen (Eds.), *Frames and concept types. applications in language, cognition, and philosophy* (Vol. 94, pp. 243–266). Heidelberg, New York, Dordrecht, London: Springer.

Petersen, W., & Werning, M. (2007). Conceptual fingerprints: Lexical decomposition by means of frames. In U. Priss, S. Polovina, & R. Hill (Eds.), *Proceedings of the iccs 2007, lnai 4604* (p. 415-428). Berlin: Springer.

Putnam, H. (1975). The meaning of 'meaning'. In H. Putnam (Ed.), *Philosophical papers* (pp. 215–271). Cambridge and New York: Cambridge University Press.

Rakoczy, H. (2010). From thought to language to thought: Towards a dialectical picture of the development of thinking and speaking. *Grazer Philosophische Studien*, *81*(1), 77–103.

Seuchter, T., & Vosgerau, G. (2011). Grounding abstract concepts: Causal indexicals and affordances. In B. Kokinov, A. Karmiloff-Smith, & N. J. Nersessian (Eds.), *European perspectives on cognitive science: Proceedings of the european conference on cognitive science (eurocogsci 2011).* Sofia: New Bulgarian University Press.

Sperber, D., & Wilson, D. (1986). *Relevance: Communication and cognition.* Cambridge and Mass: Harvard University Press.

Thelen, E. (1995). Motor development. a new synthesis. *The American Psychologist*, *50*(2), 79–95.

van Gelder, T. (1998). The dynamical hypothesis in cognitive science. *The Behavioral and Brain Sciences*, *21*(5), 615–628.

Vosgerau, G. (2009). *Mental representation and self-consciousness: From basic self-representation to self-related cognition.* Paderborn: Mentis.

Vosgerau, G. (2011). Varieties of representation. In A. Newen, A. Bartels, & E.-M. Jung (Eds.), *Knowledge and representation* (pp. 185–209). Stanford and Calif and Paderborn and Germany: CSLI Publications and Mentis.

Vosgerau, G., Seuchter, T., & Petersen, W. (in press). Analyzing concepts in action-frames. In T. Gamerschlag, D. Gerland, R. Osswald, & W. Petersen (Eds.), *Meaning, frames, and conceptual representation, studies in language and cognition.* Düsseldorf: Düsseldorf University Press.

Vosgerau, G., & Synofzik, M. (2010). A cognitive theory of thoughts. *American Philosophical Quarterly*, *47*(3), 205–222.

Weber, A., & Vosgerau, G. (2011). Is cognition grounded in action? conceptual considerations and empirical evidence. In B. Kokinov, A. Karmiloff-Smith, & N. J. Nersessian (Eds.), *European perspectives on cognitive science: Proceedings of the european conference on cognitive science (eurocogsci 2011).* Sofia: New Bulgarian University Press.

Weber, A., & Vosgerau, G. (2012). Grounding action representations. *Review of Philosophy and Psychology*, *3*(1), 53–69.