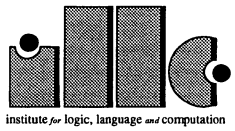

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Understanding Understanding

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In 1972, Paul Ziff published a book with the title *Understanding Understanding*, in which he remarked "to understand understanding is a task to be attempted and not to be achieved today, or even tomorrow" (p. 20). What he was able to contribute then was, in short, the following:

We distinguish understanding an utterance and understanding the statement made. The first is processing the morphological and syntactic form by way of analysing the utterance into constituents and synthesising them into the sentence; the second is performing a semantic analysis according to the constituents and synthesising the semantic parts following the synthesis of the constituents in the sentence. This so far seems self-evident compositional practice. But he pointed out further that all factors are analysable in terms of vectors which interact in determining understanding. The conditions associated with a word constitute vectors which more or less come into play depending on the contextual vectors. On p. 70 he adds" The vocabulary of words and word-senses of a natural language is a continuous creation", by which he refers to creating polysemy as a principle in language, and on p. 72 he elaborates this as " The set of conditions associated with a word is subject to constant variation. The continual modulation of meaning is characteristic of all discourse in a natural language." The set of senses of a word is, according to Ziff, more analogue than it is a digital or discrete set of senses. Earlier, in his book *Semantic Analysis* (1960), Ziff had worked out structuralist principles of morphological and semantic analysis taking place on sets of linguistic data.

I now want to present in an informal way the outlines of a theory of understanding that takes into account Ziff's starting points by integrating understanding with a dynamic data-oriented theory of concept formation.

I. The principle of concept formation:

Concept formation is creating structures (class-structures, ordering-structures, topological structures) on growing sets of data.

For linguistically guided concept formation the primary data are pairs of utterances with their satisfaction situations. The structures are classifications according to identity and difference under perspectives, ordering structures, and topological structures. Utterances are segmented according to the traditional structuralist methods of forming substitution classes according to substitutability in sets of contexts. The analysis in constituents is aided by the traditional test of positional change and paraphrasability. These structuralist methods do not lead to a unique result per sentence, but that is no problem because semantic composition can follow different routes. It is realised by now that these methods can not be purely formal, rather they heavily rely on semantic understanding because at each point, when we have to achieve some understanding, we only have a finite corpus of data to work with, and especially in the beginning of the process of forming syntactic and semantic concepts we have to start with very little data right away. The point is that this process has to take place on growing sets of data, starting already when we have relatively few data only. The results have to be modified with growing sets of data, and in principle concept formation is an on-growing process. The structures we achieve on the sets of data are therefore dynamic: they change, but not widely, and they converge to states of relative stability.

A competent speaker of a language has reached a comparatively stable state in concept formation. It depends on his normative attitude and his weight in society, how much this stability can again be threatened, or how far it stays stable and where it gets destabilised. In principle, reorganisation of the structures achieved on a set of data is always possible. Creating polysemy is a

means to hold intact old structures while putting new cases that would destabilise old classifications into newly created classes. Creating new senses or new concepts for existing words, additional to their old senses, is conservative with respect to the old structure. It adds new concepts but does not destroy old ones. Without any urge to stabilisation there would not be polysemy; and without a trend towards stability their would not be any concept formation at all.

What is important in this process of structuring or concept formation is that every stage in it is the stepping-stone for the next one: the structuring reached at a certain point is the background for dealing with new data. They are associated to those data to which they are most similar under the available perspectives, and they are dissociated from those to which they are most different under these perspectives.

Similarity under perspectives or thematic dimensions[1] is the guiding principle of integrating new data into sets of old data. The similarity is, of course, due to obvious or hidden properties of the data, which come into view under the perspective chosen. But we need not be consciously aware of these properties and do not need to have concepts of these, rather these concepts are formed as the result of classification according to the intuitive awareness of similarity under a perspective[2]. The perspective organises an alignment of data in which comparison takes place[3]. Under a perspective, for example ACTIVITY, many activity properties come into view, as there are walk, run, eat, drink, fight, etc. They form oppositions under the perspective. Similarity under this

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[1]For these notions see Bartsch 1987.

[2]Similarity is a primitive notion in this context, but it can be understood quantitatively in similarity spaces formed by sets of input sensors and connectionistic nets in several layers. Cf. Bartsch 1994.

[3]The importance of alignment in the process of comparison that leads to recognition of similarity has been stressed by Medin, Goldstone, Gentner 1993.

perspective means that the data are ordered under it into subsets with high internal similarity and high external dissimilarity under the perspective. In this way a range of concepts, opposing each other, can be constructed under a perspective. The fineness of the categorisation is guided by the use of different words under the perspective in a language, but can in principle also be made finer or coarser. Each new example viewed under the perspective of ACTIVITY will be put into one of the already existing subsets, where it fits best without destabilising its perspective dependent internal similarity and its external dissimilarity too much, or if that is not possible salva stability, it will be put into a new subset, a new oppositional concept under the perspective. The use of an expression that has already been associated with an existing subclass under this perspective makes that the new instance, if also used under the same perspective, will have to be incorporated into the existing class, even if the internal similarity degree goes down. In this way language use guides concept formation. In case the word is used under another perspective, the satisfaction situation for this use will not be incorporated in the existing subclass, rather a new one under the second perspective will be arranged, and in this way polysemy will be created. The first case, with the perspective remaining constant, is a case of concept broadening, the second, with a change in perspective, is a metaphoric or metonymic use, leading to a new concept within the polysemic complex of the word.

Similarity can be due to identity of properties or relationships. Because of the latter, things, even of quite different ontological realms, can be similar in that they stand in the same relationship to another thing. So Juliet and the sun can be similar for Romeo, who exclaimed "Juliet is the sun", in that they both create in him a feeling of warmth and well-being. In this respect they are identical. Or Mary's antique tea-pot and her friends new 10 speed bicycle can be similar in that they both are precious to them, and therefore he can shout at her "This is my tea-pot, all right", when she handles his bicycle carelessly. In both examples the things are similar for certain persons under the perspective of CAUSING EMOTIONS. And the different kinds of emotions are the cores of the relational properties that can make things similar or dissimilar under this perspective.

Perspectives can be formed by interests, purposes, tasks, emotional stance, and generally by questions asked. For example, the question "What about his health?" opens the thematic dimension or perspective of health-properties, "What flower is it?" opens the perspective under which the properties fall that define kinds of flowers. Perspectives can be simple or complex and they are part of the context in which something is perceived and understood. As the set of properties that fall under it, a perspective can be seen as a second order property. Although perspectives play a role in concept formation from the beginning, they are not available as second order properties to begin with. Rather some of them, for example COLOUR, FORM, MOVEMENT are implicit in our innate and early acquired ways of meeting the world with our senses in all kinds of activities. Further perspectives are built up in the course of developing more activities, preferences, and knowledge. Thus new perspectives and thematic dimensions are built up in the course of concept formation and general development, and also in this sense one stage is the stepping stone for the next. It forms the background on which the next question can be asked.

Primary concept formation in a speech community is guided by the public use of expressions with respect to their satisfaction situations. These kind of situations make descriptive utterances and beliefs true, or orders, requests, wishes, and plans fulfilled. Sets of satisfaction situations get extended by adding other situations which are most similar to them under the relevant perspectives. These other situations are then understood in terms of being integrated into similarity sets of previous situations, among them satisfaction situations for utterances. Some previous, not linguistically guided, concept formation may support the linguistically guided process, but linguistic usage also corrects or reorganises pre-linguistic structuring of data according to public norms.

For an expression e, be it a small non-negated sentence or an unnegated expression within a sentence, we experience satisfaction situations under a certain perspective, an interest, a task, a point of view fixed by a question. Our set of experienced satisfaction situations under perspective **P** for e grows

and with the growth more and more common aspects of these situations are cancelled out because they are not present in the new situations for *e* which are added. This process converges to a limit at which hardly any further aspect relevant under **P** is cancelled out. This means that the growing set stabilises to an internal similarity of a certain degree. We, so to speak do not learn anything new anymore about the use of *e* under **P**. The concept is stabilised. Because of the constraints enacted by the perspective, this can happen fast, in a few steps on the basis of a short series of data. Any equivalence class of similarity sets of satisfaction situations for *e* is called a *quasi-concept*, and the equivalence class of those similarity sets that do not change anymore in their internal similarity degree by adding new satisfaction situations for *e* under **P** is called *the concept expressed by e under **P***. At each point in the learning process one has a quasi-concept that can be more or less stable, depending on how large the equivalence class is. The (quasi-) concept can be represented by each member of the equivalence class. These member sets are all the maximal sets with respect to the (quasi-) concept. I now want to present in a comprised form linguistically guided formation of general experiential concepts:

We have for an expression *e*:

1. experiences of utterances: u_e, and 2. experiences of satisfaction situations: s_e, short: experienced satisfaction situations. We form sets of experienced satisfaction situations with respect to *e*: S_e. On them we form similarity sets under perspectives $\mathbf{P}^i$. These similarity sets are subsets $S_{e,i}$ of S_e, each harmonised with respect to a $\mathbf{P}^i$. This means: $S_{e,i} \in \mathbf{P}^i$.

A $\mathbf{P}^i$-harmonised subset of S_e, $S_{e,i}$, is also called a $\mathbf{P}^i$-similarity set of *e*. For each $\mathbf{P}^i$ we form a sequence of growing $\mathbf{P}^i$-similarity sets $\Sigma_{e,i} : S_{e,i} \subset S'_{e,i} \subset S''_{e,i}, \ldots$.

A **P**-harmonised sequence Σ of *e* grows monotonously by adding only satisfaction situations of *e* that conform to harmonisation under **P**. Within such a sequence internal similarity of one member set can be compared with

that of another member set. Thus, the member sets of a sequence have different similarity degrees with respect to each other.

The internal similarity degree of $S_{e,i}$ is $D(S_{e,i}) > p$, whereby p is the similarity degree already induced solely by being experiencable under the same perspective $\mathbf{P}^i$. This means that there are other contrasting expressions e' such that $S_{e,i}$ is in opposition to $S_{e',i}$ under $\mathbf{P}^i$. This prevents overextension of a concept under $\mathbf{P}^i$ (see condition (3) below).

If $S_{e,i} \subset S'_{e,i}$ in a $\mathbf{P}^i$-harmonious sequence, then the internal similarity of $S'_{e,i}$ is smaller or equal to that of $S_{e,i}$: If $S_{e,i} \subset S_{e,i}'$, then $D(S_{e,i}') \leq D(S_{e,i})$. This means that with the order relationship between the growing subsets of data there corresponds a converse ordering relationship between the internal similarity degrees of these sets.

Each largest member of a **P**-harmonised sequence of similarity sets at a certain point of time represents the *quasi-concept* of e with respect to the available set of data under perspective **P**.

$S^n_{e,i}$ is the n-th member of the sequence $\Sigma_{e,i}$. If with growing n we have $|D(S^{n+1}_{e,i}) - D(S^n_{e,i})| \rightarrow 0$, we say: The sequence of quasi-concepts stabilises.

A sequence of similarity sets is stabilised, i.e. defines a concept, if there is an $S^n_{e,i}$ in $\Sigma_{e,i}$ such that for all $S^m_{e,i}$, with $m > n$, $D(S^m_{e,i}) = D(S^n_{e,i})$. All these $S^m_{e,i}$ are members of the equivalence class $|S^n_{e,i}|$. They are called *maximal members* of the sequence. The equivalence class $|S^n_{e,i}|$ is the *experientially constructed concept.* It is experienced as depending no more on the growth of the set of data. This constructed concept is completely represented by any member of this class. A concept is a stable quasi-concept.

We now formulate what it means that a similarity set of experienced satisfaction situations completes a concept of e:

A set $S_{e,i}^n$ in a sequence Σ *completes a concept* expressed by e $=_{def}$

(1) For all m, with $m > n$: $D(S^m_{e,i}) = D(S^n_{e,i})$. i.e. stabilisation.

(2) For all $\mathbf{P}^j$, with $\mathbf{P}^j \neq \mathbf{P}^i$, and all k such that there is an $s \in S^k_{e,j}$:

$D(S^n_{e,i} \cup \{s\}) < D(S^n_{e,i})$, i.e. $\mathbf{P}^i$-harmony is distinctive in a polysemic complex.

(3) For all e', with $e \neq e'$, and all k such that there is an $s \in S^k_{e',i}$:

$D(S^n_{e,i} \cup \{s\}) < D(S^n_{e,i})$, i.e. there are oppositions under $\mathbf{P}^i$. If this condition is not satisfied, e and e' are synonyms.

Stabilisation implies that instances of satisfaction situations of e under **P** that would change the similarity degree are no longer incorporated into the concept, but are considered to be marginal or deviant cases. Stabilisation makes it possible to admit some flexibility with regard to marginal cases of use of e under **P**, without the concept being affected. They just don't get integrated. According to condition (2) adding uses of e under another perspective would destabilise the concept. They are therefore not integrated, but give rise to a new category. According to condition (3), if the perspective is the same, destabilising situations have to have to get another name than e. They belong to an oppositional concept under the same perspective, or else the concept is broadened.

Normative behaviour with respect to one's concepts means that one prefers stability. As long as cases that change the similarity degree are permitted into the similarity sets, the quasi-concept is not yet stabilised. Stabilisation is a preferred state, which can be destabilised again by massive data of satisfaction situations of e under **P** which require a change of concept. Such a destabilisation can also be reached by being overruled by norm authorities who establish other or new uses of e, or by adopting a new convention of use of e under **P**. Adjustment to pressure from the outside by massive data, or data produced by norm authorities, can temporarily overrule preference for stability. Note that in a probabilistic or connectionist model of concept form-

ation a few deviating instances likewise would not change a concept because their relative weight is small compared to the majority of well fitting instances. Large amounts of unfit data could change the concept, especially if these data themselves show some regularity which can give rise to a new point of convergence. The old point of convergence may be kept intact if it gets reinforced now and then. Thus we may get two points of convergence, especially if the expression is regularly used under two different perspectives, or two different specifications of one perspective.

A concept is co-ordinated for all members of a population if it is the same for all of them. Sameness here is equivalence of sequences of quasi-concepts, such that they have a common maximal element. In order to judge about sameness of concepts we find out whether the sequences converge to a common limit. They accept the same satisfaction situations for *e*. This means that the sets of satisfaction situations for an expression which are accepted by different language users can be united without any difference in their limits. This criterion implies that two language users have the same concept for *e* under **P** if and only if they can lump together their maximal similarity sets for *e* under **P** without experiencing a decrease in internal similarity, i.e. they can unite their concepts salva stability. This criterion, of course, implies that identity of concepts of several language users at a certain time can be a matter of degree.

Additionally to structures of classification on the set of situations, and especially satisfaction-situations, which are based on similarity under perspectives and convergence toward stability of set internal similarity, there are structures laid on the set of experienced situations which are based on space-time and causal contiguity between situations. Partial individual concepts, understood as converging toward complete individual concepts, concepts of events and actions, and concepts of places and scenes are formed as sets of situations with these contiguity relationships among them. These relationships amount to historical structures over sets of situations. A partial individual concept in this sense is a set of situations of the life-history of an individual, which are thought of standing in historical relationships making

them part of a continuant. In these 'historical' concepts, experiences about the respective entities are integrated into the structure of the continuant, which is a schema of space-time and causal connectedness of situational experiences. Integration of new situations into a partial individual concept has to take place salva continuity, i.e. keeping intact historical order of situations and the continuation and development of more permanent properties. For historical concepts integration salva stabilitate means integration under behold of continuity. Thus, if a new situation predicated about someone by the name *John* does not fit into the partial individual concept we have about John, we can keep intact stability of this individual concept by assuming another individual concept with the name *John*, into which this new situation can be integrated. This is analogous to creating polysemy for names of general concepts. The alternative would be destabilising our individual concept of John and reorganising it such that the new fact fits, either revising the individual concept by discarding some old information about John as untrue, or by taking into account the possibility of chaotic behaviour.

As soon as individual concepts, event concepts, action concepts, and place concepts have been formed, experienced situations are different from what they were in the first place. They are no more just situational impressions, rather they can now be understood and constructed as real situations by being integrated into 'historical' concepts, namely individual concepts, action-, event-, and place-concepts. They thus get analysed according to how they are built up out of participants and actions or events occurring in them at certain places and at certain times. Situations, so understood, are objective entities and not just subjective impressions or experiences.

II. The principle of understanding:

Understanding is integrating new data into the structured set of old data salva stabilitate of the established structures.

New data, for example new situations, are integrated into those concept representing subsets of situations to which they fit best under the perspective

at issue. In the best case they fit perfectly in the sense that they do not diminish the internal similarity degree of the subset they are added to under the perspective at hand. Then the new situation, the datum, clearly falls under the concept, which is represented by this subset, as a member of the equivalence class of sets that constitute the (quasi-) concept at this stage of concept formation. In other cases a new subset will be formed out of several members of the concept representing set to which the new datum is most similar under an additional specification of the perspective. This new set will not be fully integrated but intersects with the old concept defining set, except for the new member. If this is done repeatedly, we get a cluster of concepts which together form a set with merely family resemblance. In fact, it is a cluster of related concepts, which all may be expressed by the same word, for example Wittgenstein's *Spiel*. In this case, additional perspectival specifications of the overall perspective ACTIVITY are INSTRUMENT USED, NUMBER OF PERSONS INVOLVED, etc. Also clusters of concepts can be formed which are less related in that there is the same name used under different perspectives, without a governing overall perspective. These clusters are real polysemic complexes, as the complex for the word *cold*, for example. This is a complex consisting of a concept under the perspective of TEMPERATURE, another under the perspective of EMOTION, a third under the perspective of SOCIAL RELATION, and a fourth under the perspective of COLOUR. These clusters are formed in the following way:

Satisfaction situations under the perspective TEMPERATURE for instances of positive use of the word *cold* in simple sentences form the temperature concept of being cold, in opposition to other temperature concepts formed under this perspective. By switching to the perspective of the emotional result of some of these situations and adding new situations which we experience similarly under the perspective of EMOTION, even though no low temperature is involved, we form the new concept of freezing emotionally. For example the touch of an unloved person makes us feel cold and makes us react coldly. The new subset branches off from the set of situations involving cold temperature and contains new members which are not similar to them under the perspective of TEMPERATURE; rather they are similar to some central

cases under the new perspective of feeling, whereby the cold feeling arises in some events from cold temperatures. The new subset is a continuation of these cases, but now under the perspective of EMOTION. This set is the basis for the concept of emotional coldness, or for being frozen emotionally. This was a metonymic transfer: The word was transferred from the causes to the effect, an effect which can also be caused by other circumstances than cold temperature. Since in this case the effect was in some sense similar to the cause, we also see here a metaphorical transfer due to the aspect of being motionless, typical of something cold or frozen under both perspectives, the one of temperature and the one of emotion. From here branches off a new concept under the perspective of COLOUR, and one under the perspective of SOCIAL RELATION. Certain colours cause in us a similar feeling of emotional coldness as cold temperatures or certain people or other circumstances did, and these colours we call *cold*. From the effect the word is transferred to the cause in the range of colours. These steps add up to a similarity by relationship, or analogy: Cold temperatures cause a feeling of emotional coldness like certain colours, namely the cold ones, cause this feeling of emotional coldness. We can also say that the colours are called *cold* because of this analogy. Something analogous holds for social relationships between people: Such a relationship can be called *cold* because it is governed by cold feelings, and causes merely such feelings.

Creating structures of polysemic complexes of concepts, like the one of *cold*, happens in metonymic and metaphoric understanding, which consists in either delineating subsets of data under new perspectives by making use of contiguity relationships, like the cause-effect relationship, and then the delineated subset is extended by new data similar to the ones of the subset under the new perspective. Or the transfer takes place across two perspectives whereby similarity is created by certain aspects that come into view under both perspectives alike. The constraints imposed by the second perspective select aspects from those that were conspicuous under the first perspective. Linguistic use based on transfer across perspectives is conservative in that the conceptual structures are merely extended by creating new concepts expressed by the same word; they are not destroyed. Above an example was given about handling new data with respect to individual concepts: The new

data are understood by integrating them into the partial individual concept salva stability. It is interesting to recall in this connection that in psychiatry data that do not fit into a personality, and a partial individual concept generally, give rise to the assumption of split personalities, or multiple personalities in one individual, which are kind of polysemic complexes of individual concepts, which partly overlap. This is a way of being able to understand what is at hand with these individuals. After these general remarks about understanding new data, especially new situations, by integrating them into old sets of data, while keeping intact stability of the conceptual structures on them, we now shall look into understanding linguistic utterances.

Understanding a linguistic utterance is first a matter of understanding its linguistic form, which means that it has to be integrated into sets of linguistic utterances, whereby it gets classified as a type of utterance, an expression, and whereby it gets parsed into its constituents. The beginnings of this method have been made in a project of data-oriented parsing[4]. In this project it is important that the procedure works top-down, from the largest constituent, the sentence itself, to the next largest ones. Parsing a sentence or phrase works by looking for as large as possible constituents in the set of data that have already been parsed. Here I only shall address semantic understanding of utterances[5]. It is partly lexical understanding, and partly syntactic understanding. Understanding means to collect the constraints on possible satisfaction situations from the system of conceptual structures. We look for the largest parts of the utterance that can be found back in the set of data together with their satisfaction situations for these parts. For non-negated parts this means that a possible satisfaction situation for the utterance must fit salva stabilitate into the maximal, i.e. (quasi-) concept defining sets of known satisfaction situations for these parts. For negated parts the constraint is that a

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[4] This project is done at the Department of Computational Linguistics at the University of Amsterdam, for example in Scholten 1993 and Bod 1995.

[5] This is elaborated to some extent in Bartsch (ms.)

possible satisfaction situation may not fit into the sets of satisfaction situations for these parts salva stabilitate.

In principle the syntactic built up of an utterance can be followed from bottom to the top, i.e. compositionally from the smallest parts to the larger parts, following the constituent structure. But especially in the beginning of concept formation we have to start from the top and get the concepts related to the parts by way of analysis forming contrast systems of utterances, and parallel of their satisfaction situations. Thus, according to the process of concept formation we start from whole, though short enough, utterances and their satisfaction situations, and also in understanding furtheron, the procedure is most efficient by starting from top, preferring large chunks as units of analysis and going into details of the next level of constituent analysis only if no concept, i.e. no set of satisfaction situations, is available for the larger parts.

I now shall indicate shortly how some simple syntactic structures function in understanding. For a simple sentence like *John drinks*, we find other utterances in which substitution has occurred for the complement of *John*, like *John eats, John throws a ball,* etc. Likewise for the complement of *drink* or of some of the other predicates we find substitution instances. We can, hereby, form substitution sets which are syntactic categories, and parallel with these we form sets of satisfaction situations. Together with the syntactic category of sentence subject we have a parallel semantic category, which is so far the general concept 'Actor of', which is too narrow for the whole syntactic category and gets extended further on. With the category predicate there corresponds the semantic category 'Action'. Both can be extended to the broader concepts of 'Carrier of a property', and 'Predicated property', which can be an action, process or state, in which the carrier is involved more or less actively. Something similar is possible for the further segmentation of the predicate into verb, direct object, and indirect object, and furtheron prepositional phrases and adverbs. We thus can correlate with syntactic compositions analogously semantic classes of pairs which can be seen as role-concepts. The semantic role-concept 'Actor of' is the set of pairs consisting of an individual concept as actor and a situational concept as action. The role-con-

cept 'Patient of' is the set of pairs consisting of an action and the direct object of the action. To understand a new sentence of this form then means to incorporate it into such structures. This means that the constraints on the possible satisfaction situations are collected in the following way, which I shall illustrate by an example.

Understanding an utterance of the sentence *John feeds a horse* is forming the following collection of constraints on possible satisfaction situations for the sentence: If there are already satisfaction situations for this sentence in the data set, the new possible situation just has to fit into this set salva stabilitate, under the perspective ACTION. If we don't have such a situational (quasi-) concept of John feeding a horse, we have to recur to the layer of the largest constituents which are in the data set. Assume that we have a substitution set for *feeds a horse* with respect to *John* in the left context, and we have a substitution set for *John* with respect to the right context *feeds a horse* . This means that we have sets, i.e. (quasi-) concepts for both constituents formed by what is constant in these sets of data, firstly the individual concept 'John' associated with the left context of the first substitution class, and secondly the concept 'Feeds the horse' associated with the right context of the second substitution class. Then the constraints are the following.

1. A possible satisfaction situation has to be integratable salva continuity into the (partial) individual concept 'John', i.e. into the set of situations that partially make up John's life history, 2. it has to be integratable salva stabilitate into the (quasi-)concept 'Feed a horse', and 3. it has to be integratable into the relational concept 'Actor of' with respect to 'John' and 'Feed a horse'. The last condition means that the situation has to contain the smallest situation which fulfils condition 2 and which is integratable as an element into 'John as an actor', i.e. into the subset of situations in John's life-history in which he is the actor. If the data set does not yet contain a (quasi-)concept 'Feed a horse', we have to recur to the next lower constituent level, namely the (quasi-)concepts 'A horse' and 'Feed'. Instead of condition 2 we then have 2.1. that the possible satisfaction situation has to be integratable salva stabilitate into a horse-individual concept, which is an element of a set of historical structures of horse-individuals laid on the set of

experienced (satisfaction) situations for *horse*, 2.2. that it has to be integratable salva stabilitate into the maximal set of situations for *Feed*, and 2.3. that it has to be integratable into the relational concept 'Patient of' with respect to some individual horse-concept and the situational concept 'Feed'. This means that the feeding-situation has to be a smallest situation which is a member of a partial individual concept of a horse in the role of patient, i.e. it has to be part of the life-history of a horse as far as it is in the role of patient to an action. The requirement that it should be, or contain, the smallest situation fulfilling the constraints excludes that a bigger situation satisfies the constraints which could contain a horse in the role of patient to some other action than the feeding while the feeding would be an action in the situation directed towards some other individual than a horse. The same requirement of taking the smallest situation holds for condition 3 above, where the two constituents were semantically connected by the Actor-relationship. A possible satisfaction situation for such a sentence must be, or must contain the smallest situation that satisfies all the constraints of a syntactic composition. This is the construction requirement on possible satisfactions which is meant by what is called the semantic synthesis according to the composition of the syntactic parts.

We had distinguished understanding new situations from understanding utterances qua form and qua content. However, we may conclude that understanding in all three cases is the same basic operation, namely comparing new data with old data under perspectives and integrating them salva stabilitate into subsets of data formed according to similarity under perspectives, and salva stabilitate into subsets that are bound together under factual historical contiguity. Thus integration amounts to classification and to identification of individuals and space-time regions on which events and actions take place and states hold. This integration is always an integration into structured sets of situations, which keeps the structure stable, and by requiring a possible satisfaction situation to be a smallest one, a synthesis takes place between the parts that are identified by integration into subsets that have been formed previously. In those cases where integration salva stabilitate of set-internal similarity under a perspective is not possible, new sets are created that branch off from old ones under new perspectives, by using

similarity under the new perspective and relationships of factual contiguity with situations which are members of sets which have been formed previously. Understanding goes hand in hand with concept formation. Both are an on-going process. Unproblematic understanding strengthens the stability of concepts, problematic understanding, where integration salva stability is not possible, leads to the creation of new concepts. Note that in normal discourse one does not discard data easily as being contradictory to ones conceptual structures. Rather Quine's principle of charity, or Davidson's of humanity, is assumed, which here revises interpretation by construing other new concepts into which the problematic data will fit salva stabilitate of the overall conceptual structure, which consists of general and historical concepts as structures on the growing sets of data, with set-internal stability by similarity under perspectives or set-internal stability by established factual contiguity.

References

Bartsch, Renate. 1987. The Construction of Properties under Perspectives. In: *Journal of Semantics 5*: 293-320.

Bartsch, Renate. 1993. Concept Formation and Understanding: An Overview. In: D. Nauta, A. Nijholt, J. Schaake (eds.), *Pragmatics and Language Technology. TWLT 4*: 71-86.

Bartsch, Renate. 1995. The Relationship between Connectionist Models and a Dynamic Data-Oriented Theory of Concept Formation. ILLC Research Report LP 94-19. Institute of Language, Logic, and Computation. University of Amsterdam. To appear in *Synthese.*

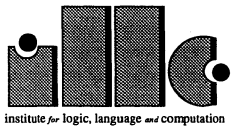
Bod, Rens. 1995. *Enriching Linguistics with Statistics: Performance Models of Natural Language*. ILLC Dissertation Series 1995-14. Institute of Logic, Language, and Computation (ILLC), University of Amsterdam.

Medin, Douglas L., Goldstone, Robert L., Gentner, Dedre. 1993. Respects for Similarity. In: *Psychological Review*, Vol 100, No. 2: 254-278.

Scholtes, Jan. 1993. *Neural Networks in Natural Language Processing and Information Retrieval.* Ph.-D. Dissertation. Institute of Language, Logic, and Computation (ILLC). University of Amsterdam.

Ziff, Paul. 1960. *Semantic Analysis*. Ithaca, New York: Cornell University Press.

Ziff, Paul. 1972. *Understanding Understanding*. Ithaca and London: Cornell University Press.



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