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# ON VALENCE-BINDING GRAMMARS 

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## SUMMARY

The valence of a verb determines the number, and the syntactic class, of those expressions that must co-occur with it in a sentence. Definitions of "valence-term" and "valence-boundness" are provided whereby the precise conditions are formulated that a valence-binding grammar must.satisfy. These conditions are exemplified in the framework of a simple categorial grammar, in which various reductions of the general notions can be carried out.

The use of such terms as "valence" and "valenceboundness" in grammatical theory implies two things. First, the terms must correspond to observable facts about natural languages or -- and this amounts to pretty much the same in terms of linguistic methodology -they must reflect certain intuitions of the linguist. Second, such terms are to be defined either by means of an operational procedure, such as syntactic tests, or in terms of a specific linguistic theory.

What, then, are the linguist's intuitions about valence? Tesnière ${ }^{2}$ describes the valence of $a$ verb as the property of that verb to take a certain number of actants. Similar characterizations can still be found in recent papers about the subject, ${ }^{3}$ the only difference lying in the fact that the application of the term "valence" is extended to classes of expressions other than verbs.

The empirical reason for ascribing valence to verbs lies simply in the fact that there are different classes of
verbs that behave syntactically in different ways. For example, come must be combined with one noun-phrase to form a sentence, whereas hit must be combined with two noun-phrases:
(1) John comes.
(2) John hits Bizl.

If an occurrence of $a$ verb of valence $n$ together with $n$ occurrences of noun-phrases forms a sentence, we say that the noun-phrases are ACTANTS of that verb-phrase occurrence, or, equivalently, the noun-phrase occurences are dependent on the verb-phrase occurrence. Notice that it will not do to say that the noun-phrases are dependent on the verbphrase, for there might be different occurrences of one noun-phrase not all dependent on the same verb such as in (3).
(3) He believes that he will win.

Sentence (3) not only shows that not all noun-phrase occurrences in a sentence need to be dependent on a certain verb-phrase occurrence, it also shows that occurrences of expressions other than noun-phrases may equally well depend on a verb-phrase occurrence. Cf. (3) where that he will win depends on believe.

Hence, some further specifications are in order. First, the notion of valence is to be specified in such a way that not only the number of actants (i.e. dependent occurrences of expressions) is specified, but also the syntactic classes of these actants.

In order to state that a verb $a$ can take $n$ actants of some syntactic class $A$, we will say that $a$ is $n$ times valued for $A$. Since the actants may be in different classes, we allow a verb to be valued for an arbitrary number of classes, e.g. if $a$ takes $n$ actants of class $A$ and $m$ actants of class
$B$, we will say that $a$ is $n$ times valued for $A$ and $m$ times valued for $B$ and so on.
(V1) If $a$ is $n$ times valued for $A, a$ is $n A-v a l u e d$.
(V2) If $a$ is $u$-valued and v-valued, it is (u,v)valued.
(V3) The valence of $a$ is $u$ if and only if $a$ is u-valued and there is no nA such that $a$ is ( $u$, $n A$ )-valued for $n>0$.

Now, we do not want to distinguish between, say, (1N,1N)and $2 N$-valued verbs ("N" for "noun-phrase"). We therefore state the principle (V4):
(V4)

$$
(n A, m A)=(n+m) A
$$

Nor do we want to distinguish between (u,v)- and (v,u)valued verbs, so we state (V5).
(V5) $\quad(u, v)=(v, u)$
Furthermore, if $a$ verb is $n$-valued and $v$-valued and w-valued, by (V2) it is either ( (u,v),w)-valued or ( $u,(v, w)$ )-valued, which of course should be the same. Consequently, we state (V6).
(V6) $\quad((u, v), w)=(u,(v, w))$
Since, by (V6), internal bracketing is irrelevant for valenceterms, ${ }^{4}$ we conventionally write only the outermost pair of brackets.

Principles (V4), (V5) and (V6) are what in algebra are known as the distributive, commutative, and associative laws respectively. If in addition we take (V1) as the definition of multiplication and (V2) as the definition of addition, we can characterize the set of valence-terms as an algebraic structure. Further details need not detain us here.

If we now add two principles concerning valence-terms containing " 0 ", we get a very useful generalization:
(V7) $\quad 0 A=0$
(V8) $(v, 0)=v$
By these principles, the "absence of valence", or zerovalence, can be handled in a straightforward manner. For, if we call it rains a zero-valued verb, we do not want to say that it takes zero actants of one special syntactic class, but rather that it takes no actant of any class. Therefore, it would be somewhat misleading to characterize it as $0 \mathrm{~N}-$ valùed, for instance. ${ }^{5}$ If we characterize it simply as 0 -valued and use (V7), we are able to derive formally its property of being $0 N-v a l u e d$ (or $0 s-v a l u e d$ or ... for all classes). By (V8) ON-valued is the same as ( $0 \mathrm{~N}, \mathrm{O}$ )-valued which, by (V7), is the same as (0N,OS)-valued and so on. Thus the valence 0 is defined as zero-valued for all syntactic classes.

Furthermore, other verbs taking actants are "automatically" characterized as being zero-valued for all those syntactic classes from which they do not take actants.

Second, we must specify which occurrences of expressions (of appropriate syntactic classes) are dependent on the verb occurrences in the sentence. As for sentences like
(2) John hits BiZZ.
no problem arises. Hit is 2 N -valued and just two nounphrases occur in (2), therefore they depend on hit. If more than two noun-phrases co-occur with hit as in
(4) John hits Bill with a club.
again John and BilZ are regarded as actants, but not a club. Clearly, if once we have decided to classify hit as $2 \mathrm{~N}-$
valued, only two noun-phrase occurrences can depend on hit, but why not $a$ club instead of, say, Bill. It is common to say that only structurally necessary constituents can be actants, and only those that cannot be eliminated without rendering the remaining expression a non-sentence are structurally necessary. ${ }^{6}$

As Hartmut Günther points out (1978, in this volume) this criterion is not a sufficient one to single out all actants -- e.g. the direct objects of some transitive verbs. However, if it applies, the eliminated expression is necessarily an actant of the verb in question.

Now, if we eliminate $a$ club alone from sentence (4), the remaining part
(4') John hits Bill with.
would be a non-sentence and therefore $a c l u b$ should be regarded as actant. This, of course, is not the intended version of the elimination test. What is meant is rather: elements of a sentence are structurally necessary when they are NOT PART OF AN EXPRESSION THE ELIMINATION OF WHICH LEADS TO ANOTHER SENTENCE. Since $a$ club is part of with $a$ club -- which can be eliminated -- this formulation yields the intended result. It implies that with $a c z u b$ is to be regarded as a constituent of the sentence. Thus, the revised version of the elimination test does not allow for analyses that treat with as an expression that augments the valences of verbs, i.e. as an expression that gives an ( $n+1$ ) N-valued verb if used together with an $n N$-valued verb.

We are now able to state the conditions a grammar must meet if valence-boundness is to be stated within that grammar: IT has to ASSIGN A VALENCE TO EACH VERB OF the language and it has to state that those and only those $n$ EXPRESSIONS OF A SYNTACTIC CLASS A THAT DO NOT OCCUR WITHIN LARGER EXPRESSIONS ARE BOUND BY THE VALENCE OF AN nA-VALUED VERB WHEN COMBINED

WITH that verb.
Apart from this, our criteria for valence-boundness do not commit us to specific grammars. For example, they allow for grammatical rules that combine $n$ noun-phrases with an nN-valued verb as well as for rules that combine just one noun-phrase with an nn-valued verb, the resultant expression with another noun-phrase, and so on. These criteria are thus to be regarded as metagrammatical conditions on grammars specifying valence-boundness, and we may call a grammar $G$ (for a given language L) "valence-binding" if these conditions can be stated within $G$. To be more precise: G is valence-binding if and only if it possesses the following three properties.
(VBG 1) G ASSIGNS A VALENCE TO EACH BASIC VERB-PHRASE OF L (VERB IN THE LEXIKON).
(VBG 2) IF $b_{1}, \ldots, b_{m}$ ARE EXPRESSIONS OF THE RESPECTIVE SYNTACTIC CLASSES $B_{1}, \ldots, B_{m}$ IF $c$ IS AN EXPRESSION CONTAINING AN OCCURRENCE OF A VERB $a$, AND IF FURTHER $b_{1}, \ldots, b_{m}$ AND c COMBINE TO YIELD AN EXPRESSION $d$ ACCORDING TO THE RULES OF G, THEN THE OCCURRENCE OF $b_{i}(1 \leqq i \leqq m)$ NOT CONTAINED IN $c$ IS BOUND BY THE VALENCE OF THE OCCURRENCE OF $a$ IN $d$ IF AND ONLY IF THE VALENCE OF $a$ IS
( $n_{1} B_{1}, \ldots, n_{m} B_{m}$ ) AND THERE ARE AT MOST $n_{i}-1$ OCCURRENCES of expressions of class $B_{i}$ in $C$ bound by the valence of a.
(VBG 3) FOR EACH COMPLEX EXPRESSION $c$ GENERATED BY G THE FOLLOWING hOLDS: IF $c$ BELONGS TO THE SAME SYNTACTIC CLASS AS VERBS OF VALENCE $\left(n_{1} B_{1}, \ldots, n_{m} B_{m}\right)$, THEN THERE IS AN OCCURRENCE OF A VERB $a$ IN $c$ SUCH THAT $n_{i}$ OCCURRENCES OF THE EXPRESSIONS OF CLASS $B_{i}(1 \leqq i \leqq m)$ CAN STILL BE BOUND BY THE VALENCE OF $a$.

Some additional remarks on the definitions are required. Since we claim to define valence-binding with respect to all simple verb-phrases, all those grammars are excluded by (VBG 3) that allow for constituents such as hit with, simply because it seems impossible to obtain a decision procedure for the actants of hit alone. For the same reason (VBG 1) requires a valence assignment only for simple verbs. The import of (VBG 2) will be clarified by the examples given below. I would like to add only that $I$ am not very happy with the condition "if $b_{1}, \ldots, b_{m}$ and $c$ combine to yield an expression $d$ according to the rules of G" in (VBG 2) because of its being too imprecise on the one hand and too precise on the other hand. One might be led to the conclusion that a linear concatenation of the expressions $b_{1}, \ldots, b_{m}, c$ is the only way a grammar "combines" expressions.
But there are other devices as well. See, e.g., the following phrase'structure rules:

$$
\begin{aligned}
D & \rightarrow B_{1}+\ldots+B_{m}+C . \\
B_{1} & \rightarrow b_{1} \\
& \vdots \\
B_{m} & \rightarrow b_{m} \\
C & \rightarrow c
\end{aligned}
$$

Concatenation applies here to the auxiliary symbols, not to the expressions of the language. It should be understood, however, that the aforementioned "combine" comprises this and similar cases as well. Though a formal and unified treatment is possible, I have deliberately excluded it here because of the enormous technical apparatus that would be required.

As an example of a valence-binding grammar let us
select a grammar that defines (Cresswell (1973)) a "pure categorial language". The main reasons for this choice are its relative simplicity, which enables us to ignore the problems described in the preceeding paragraph, as well as the fact that there is some recent work on valencebinding within this very framework.

A pure categorial language can be regarded as a set of categories, in which each category is a set of expressions that behave syntactically in the same way (or belong to same syntactic class, as we said above). If so, a (pure) categorial grammar is the definition of all categories. First, we have to list the symbols (or names) for the different categories. We could take any symbols that are not expressions of the language, but it is common to use special symbols that reflect directly the combinatorial properties of the expressions in the respective category. Thus, let CAT be the following set of category-symbols:
(Cl) CAT IS THE SMALLEST SET SATISFYING THE FOLLOWING CONDITIONS:

S, C, N ARE IN CAT.
IF $A \in C A T$ and $B \in C A T$, then $(A / B) \in$ CAT.
The "basic categories" $s, c, N$ are the categories of sentences, common nouns, and noun-phrases respectively, the "derived categories" (A/B) are all categories other than s or N or C . We always omit the outermost pair of brackets, so we write for instance " (S/N)/N" instead of " ((S/N)/N)". The definition of each category $A \in C A T$ is then as follows:
(C2) A IS THE SMALLEST SET SATISFYING THE FOLLOWING CONDITIONS:

A CONTAINS AS ELEMENTS ALL BASIC EXPRESSIONS OF THE CATEGORY A.

IF THERE IS A CATEGORY B $\in$ CAT SUCH THAT (A/B) $\in$ CAT AND $a \in(A / B)$ AND $b \in \operatorname{B}$, THEN $a b \in A$.

This definition says that each category contains all words (or lexical entries) of this category and all those complex expressions that are combinations of expressions $a$ and $b$ of the respective categories $A / B$ and B. For present purposes it is not too important whether the combination $a b$ is specified as a linear concatenation or as some otherwise organized complex expression formed out of $a$ and $b$, so we may also write $b a$ instead of $a b$ if this ordering is required by the rules of some specific language. What is presupposed is only a syntactic device that generates $a b$ in a welldefined manner.

Examples: Let us postulate:

| girl, club | $\epsilon$ | C |
| :--- | :--- | :--- |
| a, the | $\epsilon$ | $\mathrm{N} / \mathrm{C}$ |
| John, Bizl | $\epsilon$ | N |
| it rains | $\epsilon$ | S |
| come | $\epsilon$ | $\mathrm{S} / \mathrm{N}$ |
| hit, kiss | $\epsilon$ | $(\mathrm{S} / \mathrm{N}) / \mathrm{N}$ |
| with | $\epsilon$ | $((\mathrm{S} / \mathrm{N}) /(\mathrm{S} / \mathrm{N})) / \mathrm{N}$ |

To show the generation of complex expressions, we use analysis-trees, where each complex expression occupies the node immediately above its constituents; to the right of each expression we write its category.



The definition of the property of valence-binding within this grammar, i.e. the specification of (VBG 1), ..., (VBG 3) for the grammar, is easily accomplished. Since each syntactic class of possible actants corresponds to a category, valence terms can be formed in a straightforward way be means of categorial symbols, Thus, in order to satisfy (VBG l) we state:

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vaLENCE 0: it rains
VALENCE 1N: come
VALENCE 2N: hit, kiss
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To satisfy (VBG 2), all we need to do is take it as part of the grammar. For "syntactic class", however, we reformulate "category". Since with is an element of ((S/N)/(S/N))/N, it first combines with a noun-phrase and then with an in-
transitive verb-phrase. Consequently, expressions which are disallowed by (VBG 3) cannot be generated.

The analysis-trees (Al), (A2), (A4) show that the definitions yield the intended result.Let us consider (A4): the occurrences of John and Bill in the sentence are bound by the valence of hit, because Bill is combined with hit, where no expression is bound, and John is combined with hits Bill with a club, where one expression is bound. Though a club is a noun-phrase, it is not bound by hit, because it is not directly (as a noun-phrase)
combined with an expression containing hit.
The next example shows how INFINITIVE- phrases can be treated within this frame-work:
(5) John forgets to kiss the girl.

Since there are sentences such as
(6) John forgets the story.
where forget takes an ordinary noun-phrase as an object, one could try to treat it as an element of the category $(S / \mathrm{N}) / \mathrm{N}$. Consequently, to kiss the girl is to be regarded as a type of noun-phrase.

However, this approach yields an undesired result since ungrammatical expressions like
(7) *John hits to kiss the girl.
can be generated. Problems of a related sort arise if we take the infinitive as an expression of the category $\mathrm{S} / \mathrm{N}$, i.e. as an ordinary intransitive verb-phrase. One way to avoid such difficulties is to introduce a new category inf of infinitive-phrases that may be regarded as a subcategory of either $s / N$ or $N$ or even $s$.
$T O$, then, is to be regarded as forming infinitives out of intransitive verb-phrases. Consequently, we have to add to the grammar:
forget $\in(S / N) / I N F$
to $\in \operatorname{INF} /(S / N)$
The result for the analysis of (5) then is:


Since the occurrences of John and to kiss the girl are to be actants of forget, its valence is (1N, 1INF). The above principles then determine that John and to kiss the girl are bound by the valence of forget and that John and the girl are bound by the valence of kiss.

Our concept of valence-boundness has one special feature: an occurrence of some expression may depend on more than one verb occurrence, as is the case with John in our last example.

In classical dependency theory only one expression is allowed to be the regent of some actant, the reason for this restriction lying in the fact that dependency relations were used to $w r i t e g r a m m a r s . ~ A c c o r d i n g l y$, dependency structures are to be represented by trees where every node can be dominated by no more than one other node. So multiple dependency is not possible.

Since we do not claim to write a dependency grammar, but, rather, to reconstruct formally the intuitive notion of valence-boundness within existing grammars, no restriction of this kind is needed. The use of multiple dependency is in no way obligatory, and, consequently, it may be in order to provide some reasons why we have in fact used it. ${ }^{11}$ If we require that John in (5) is not in a dependency relation to kiss, we must regard kiss as 1 N -valued in the infinitive phrase; or, provided we regard this occurrence of kiss as 2 N -valued, then one of its noun-phrase places must be regarded as unoccupied. Either solution somewhat weakens the concept that all actant places of a verb have to be occupied if it occurs in a well-formed sentence.

This line of reasoning can also be corroborated by an empirical argument. It has been suggested in Frosch (1977) that a reflexive pronoun occurs instead of a personal pronoun in just those cases where it is dependent on the same verb occurrence as its antecedent. If multiple dependency is allowed, reflexivization phenomena within infinitive phrases can be described along the same lines. In a sentence such as
(8) John likes to see himself.
the antecedent of himself, John, is dependent on like and on see. Thus, it is dependent on the same verb occurrence as the pronoun, which must therefore occur in its reflexive form. In this way such notions as "simple sentence" and the "raising" process of transformational grammar can be replaced by a simpler principle.

So far, instead of a categorial grammar, other formal, non-categorial, grammars could have served equally well as examples. This categorial system, however, allows for
certain simplifications in the definition of valence-boundness (or dependency).

First of all, the valence of each verb is completely determined by its categorial status, since all verb categories are formed with the help of the category $s$ and all and only the actant categories of the verb. Consequently, the valence of a verb can be defined as follows: ${ }^{13}$
(CV) IF $a$ IS A VERB OF CATEGORY $S$, ITS VALENCE IS 0. If $a$ IS A VERB OF CATEGORY A/b and A IS THE CATEGORY OF VERBS OF VALENCE $u$, THEN THE VALENCE of $a$ IS ( $u, 1 \mathrm{~B}$ ).

As a consequence, the valence of forget, for example, can be calculated in the following fashion: its category is ( $\mathrm{S} / \mathrm{N}$ )/INF, so its valence is ( $u$, 1INF) by dint of the second part of (CV). By dint of the same section of (CV) we get: the valence of verbs of category $S / N$ is ( $v, 1 \mathrm{~N}$ ). According to the first clause of (CV), the valence of verbs of category $s$ is 0 . The substitution of $v$ and $u$ therefore yields ( (0, 1N), 1 INF). Following (V5), (V8) and the convention by which internal brackets are omitted, the following equațions hold: $((0,1 N), 1 \operatorname{INF})=((1 N, 0), 1 \operatorname{INF}))=$ ((1N), 1 INF$)=(1 \mathrm{~N}, 1 \mathrm{INF})$. The valence of forget, then, (or any other verb of the same category) is (1N, 1 INF).

Furthermore, since the definiendum can always be replaced by its definiens (provided the definition is correct), (CV) allows us to substitute the concept of valence by the concept of category. In other words, we can regard principle (VBG 1) as being A PRIORI fulfilled within this grammar.

A further reduction can be obtained on the basis of (C2). It is convenient to introduce some additional
terminology for this purpose. Let us call the occurrence of $a$ in an expression $a b$ formed according to (C2), the "OPERATOR of $b "$; and let us call the occurrence of $b$ in this expression the "OPERAND of $a{ }^{\prime \prime} .14$

Given all this it can be shown by way of (C2), (CV) and the principles concerning valence and valence-boundness that the following holds within our categorial system:

> (CVB) THE OCCURRENCE OF AN EXPRESSION $b$ IS BOUND BY THE VALENCE OF AN OCCURRENCE OF A BASIC VERB $a$ IF AND ONLY IF $b$ IS OPERAND OF AN EXPRESSION $c$ CONTAINING THIS OCCURRENCE OF $a$.

> As an example of (CVB) let us take (5),
the generation of which is represented by (A5) above: since the operands of the expressions containing kiss are John and the girl, John and the girl are the actants of kiss in (5), in accordance with (CVB). The operands of the expressions containing forget are to kiss the girl as well as John; they are thus the actants of forget in (5) according to (CVB). Thus, by dint of (CVB), both the concepts of valence and of valence-binding are replaced by the concept of operand.

Now, (CVB) ((CV) and A FORTIORI the (VBG)-principles) presupposes a prior decision as to which basic expression of the language is to be regarded as a verb. Since there are only finitely many basic verbs in natural languages, a simple enumeration of these will do. We may also take morphological and finally syntactic properties as criteria for verbs. In this latter case, a definition of "possible verb category" on the form of the category symbol would be required. Once this were attained, a further reduction in the definition of valence-bourdness could be arrived
at viz., if "basic expression of a possible verb category" were substituted for "basic verb" in (CVB). I shall not try to elaborate on such a definition here, since I do not believe that formal properties of categorysymbols alone are sufficient.

The following, however, can be said tentatively: As a minimal, and necessary, condition on possible verb categories one can take, for example, the restriction that verbs never occur as "attributes". Following the suggestion made by Vennemann (1977 a,b) and Günther (in this volume), that "attribute" be defined as an operator of any category of the form $A / A$, we can then exclude verb categories of this form. However, Günther's discussion of verbs such as try makes clear the difficulties to which such a definition leads: either this specific definition has to be dropped altogether, or (at least) a few modal verbs can no longer be treated as verbs (or valence-binding expressions, in the sense of Günther's definitions). To this line of argument, there is one further argument to be added. Think of the German Er wird kommen wollen. Wollen, ih this structure, is either an element of ( $\mathrm{S} / \mathrm{N}$ )/( $\mathrm{S} / \mathrm{N}$ ) and hence no verb, or, we can regard the infinitive kommen as an element of INF, and wollen as an element of INF/INF. It could then be argued that the verb stems are elements of some category $A / B$, where $A \neq B$, and, consequently, that the infinitive morpheme should be treated like English to, i.e. as an element of (INF/INF)/(A/B) for wollen. However, if morphological suffixes are treated as elements of categories, the same will have to apply to German attributive adjectives. This leads to the undesired result that the adjective stem, which is not an element of $c / c$, would no longer be defined as attribute of its head-noun.

To conclude the discussion of possible simplifications, I would like to emphasize that (CV) and (CVB) should not be taken as arguments for giving preference to this categorial system in the description of languages, even though it allows an attractively simple definition of valence-binding. The reason for this disclaimer is that, among other difficulties, a semantic interpretation of this syntax might prove to be extremely laborious. Nor should it be concluded that simplifications of the general principles, especially in those analogous to (CV), are not possible in other grammars.

## NOTES

1
My thanks go to Joachim Ballweg, Caroline Cabarth, Hartmut Günther, and to Alan Kirkness. It was only with their help that $I$ was able to finish this paper.

2

3

4
Let us take "valence-term" as denoting the prefix "v" of an expression "v-valued". Thus every valence is denoted by a valenceterm. However, conversely, there are valence-terms not denoting a valence, i.e. in cases where condition (V3) is not met.

The definition does not say that each category contains basic expressions; it does not say either that each category contains any expression at all. Indeed, most of the categories are empty, and since there are infinitely many, infinitely many categories are empty.

9
This analysis is found in Cresswell (1973), 169ff.. It is also discussed in Günther's paper.

10
Subcategories are subsets of the respective main categories. So, even if elements of a subcategory behave syntactically different in comparison to elements of the main-category, they receive the same semantic interpretation. The decision as to which category INF should be a sub-category of is mainly dependent on the proper semantic treatment of infinitives. This cannot be discussed further here.

Ballweg's definition of valence-boundness (in this volume) gives rise to multiple dependency in the same way, though he does not explicitely discuss this topic.

12
I use both terms in the same sense, since if an expression is an actant of some other expression, it is dependent on this expression following the usual terminology. See however, Günther's paper in this volume for a different point of view.

13
This definition extends Vennemann's definition of n-place verbs to arbitrary categories. (See Vennemann (1977), p. 290)
14
The terms "operator" and "operand" (or "functor" and "argument")
are commonly used in syntax to express that the semantic counterpart of $a b$ (i.e. the denotation of $a b$ ) is the value of the function denoted by $a$ for the argument denoted by $b$.

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