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# Constructive Interpretation and Text Transformation

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This paper considers the project of active transformation of texts through the substitution of words, for instance by the 'N+7' method of the Oulipans, which replaces each noun in a text by the seventh subsequent noun in a particular (print) dictionary. This method is conservative in that it only allows for intracategorial substitutions; the present paper aims to extend existing semantic interpretative mechanisms in order to handle intercategorial substitution. A type shifting system is proposed for this purpose, and applied to an example, followed by discussion of implications and extensions of the system.

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## 1. Project

Texts can be viewed as settled, concrete objects. Most literary work is meant to be a closed and inviolable whole, which is constructed by the author and which cannot be modified by the reader. This is a fundamentally passive notion of 'reading' which removes a great deal of agency from the reader, who is not free to alter the text, rephrase it, or interject their own words or ideas, except at the level of interpretation. Even there, the understanding of the reader is often called into question as a misinterpretation, as inconsistent with the source text, as out of alignment with the intentions of the author. But this way of thinking seems excessively limiting: reading of course can be a passive activity, but it should, potentially, also be an active one.

What constitutes active reading in the sense meant here? There are many ways to actively engage with a text by manipulating it or interpolating new elements with it, as discussed by Goldsmith (2011). One could for instance insert any kind of content: words, sentences, paragraphs; one could lop off large chunks of the original text, from modifiers up to whole chapters; one could rearrange things wildly and make an entirely new story, or introduce a completely novel and unfamiliar worldview. But these acts are ultimately perhaps not so different from simply writing entirely new texts. It seems much more productive and interesting to constrain the process in some way.

With this notion of constraint, I take my inspiration from the Oulipo, a mostly French collective of writers who imposed constraints on their writing and on their texts (Becker 2012; Elkin and Esposito 2013; see also Schiavetta 2000 for more on the general notion of constraint employed here). Perhaps the most famous example of an Oulipan text is Georges Perec's *La Disparition*, a novel in which the letter e never appears, though there are many others, such as Anne Garréta's *Sphinx*, a love story in which the gender of the lovers is never indicated, a much more difficult task in the French in which the book was written than in English. A constraint of another type is the so-called 'Transposition N+7' invented by Jean Lescure (Lescure, 2018), in which each noun is replaced by the noun falling seven nouns after it in the dictionary; this last is closest to what I have in mind here.

The constraints above are interesting and, at least in some cases, have led to work of substantial artistic and literary interest. But they aren't really suitable for active reading: eliminating every *e* from a text, for instance, would yield either a large number of truncated words or require extremely extensive rephrasing, both of which seem outside the genuine scope of *reading* as normally construed. What, though, about Transposition N+7? This constraint seems to have similarities to what has been discussed so far in the present work: transposing and substituting words. The difference is only that the substitution is sourced externally to the original text, to the dictionary, so it is in some sense more transformational than a notion of reading should perhaps be. I conclude from all this that an interesting constraint to apply to a notion of active *reading* is that all substitutions and changes should stem from the source text, which is to say that all material drawn upon should be text-internal. Of course, this is only one possible constraint, but it is the one that will inform the text transformations carried out in the remainder of this paper, and the semantic system that supports them.

There is a fundamental conservatism in the N+7 constraint: it allows only substitutions of nouns. A slightly more liberal system 'W+7' enables substitutions within any lexical category: verbs, adverbs, and so on. But now consider a more radical system of active rewriting of texts where any term can be (universally) substituted for any other. Such a system is likely to produce much more radically different texts, and texts of radically new types; but there are obvious difficulties. In some cases, such substitutions will not cause problems for semantic interpretation: for instance, if a nominal like *tree* is universally substituted for an adjective like *blue*, the set of interpretable semantic parsetrees will remain constant, for (on many theories of adjectives, at least) the two both have the same semantic type, namely *<e, t>*.[1] But many other substitutions will lead directly to problems in interpretation. How is one to interpret a noun or adjective when it is substituted for a determiner such as every, which are standardly given the type of generalized quantifiers (i.e. *<<e, t>, <<e, t>, t>>*), or vice versa? In fact, it is not so obvious how to interpret strings like *Tree every light or Mayonnaise some blue*, a situation which only gets more extreme as complexity increases (*Parquet blue each some and opposition tree or sweet if at*).

But if one wants to push the project of text transformation to its limit one is faced with a difficult choice. One must either give up on producing interpretable texts, which removes much of the interest of the project (and, arguably, of its artistic merit, for an uninterpretable literary text is of relatively limited interest compared to interpretable ones), or one must find a way to interpret strings like those above. Doing so is the goal of the present work and is carried out in §3, after a brief explication of the background theory and method in §2. This opens the Oulipan tradition to a new domain: previous work has applied constraints to text construction, but only within the bounds of normative interpretations of natural language. The project reported on here opens the door to a new kind of practice which functions on an interpretative level.

This goal is of independent interest: what would a language of infinite flexibility look like? What happens when certain constraints on language construction and structure are eliminated, for instance that only determiners can have denotations of generalized quantifier type? These constraints are often considered to be empirical in nature, and, construing this term as referring to existing (linguistic) systems, perhaps they are indeed empirical; but there is in principle no reason other kinds of languages could not exist, and an exploration of the space of potential systems is interesting in its own right. Further, the construction of

1. The discussion from here involves the system of type-theoretic combinatorics standard in formal semantics: see Heim and Kratzer (1998) for an accessible introduction and Montague (1974) for the foundational text.

linguistic and mathematical systems is (to my knowledge) almost unknown as an artistic practice, possibly for reasons of complexity or the required expertise. This lacuna in the space of artistic expression is one that should be filled, and, from this perspective, projects of the kind comprising this work is one that should be pursued for itself, not merely as a vehicle for enabling other sorts of artistic practice (here: text rewriting and 'active reading').

The work described here can therefore be viewed as a first exploration into a larger domain of abstract and conceptual art taking as its toolkit linguistic and mathematical systems. But this exploration is, in the present context, mostly at the service of text transformation, a detailed example of which within the proposed system is provided in §4; the reader who is uninterested in mathematics is free to skip the previous technical part in favor of the larger project.

## 2. Background theory and methodology

The system I propose for interpreting texts where unlimited tranformation is allowed is set within a formal semantic system for analyzing linguistic meaning. There are two main aspects of such systems relevant to the present discussion: the kinds of things meanings are taken to be, and the way in which they are derived.

Formal semantics has its roots in analytic philosophy, in particular philosophy of language; philosophy of language in turn has its roots in logic. In standard logics, the notion of truth is fundamental: sentences are taken to denote truth-values, true and false in the most basic systems, which is then extended to various other kinds of values in other systems. Propositional logics concern themselves only with sentence-level phenomena, but first-order logics also make reference to predications and other things which operate at the subsentential level; still, the fundamental notion involves truth, so subsentential objects are understood in terms of how they contribute to the truth of sentences. Thus, the basic first-order analysis of the sentence *A badger sleeps* can be written $\exists x[\textit{badger}(x) \wedge \textit{sleeps}(x)]$ in modern notation, where *badger* and *sleeps* are understood as sets of individuals which are true of the variable $x$ if whatever object is selected by the variable can be found in the relevant set: the quantifier $\exists x$ then allows modulation of the object the variable selects (via manipulation of an assignment function), and the whole is true just in case there is some individual which satisfies both predicates (see e.g. Gamut 1991 for an accessible introduction geared toward those interested in natural language).

Within linguistics, this background logical framework has been extensively applied in theories of the semantics of natural language which aim at providing meanings for the infinitude of possible sentences. These theories are commonly used together with views of syntactic structure in which sentences are modeled using tree structures, which themselves aim at giving structural analyses of all possible sentences (see Chomsky 1957 for an early exemplar of such a syntax). The aim is to give a system in which, when two words appear adjacent together in the hierarchical structure derived from a set of phrase structure rules (or similar method), the meanings of the two can combine into a new meaning reflecting both.

In such theories, natural language expressions are associated with mathematical objects, their *denotations*. These objects consist of two elements and have the form $\varphi : \gamma$. Here, the first element $\varphi$ consists of expressions of the λ-calculus, a mathematical system for representing functions and their arguments (Barendregt, 1981). The leading idea is that when two expressions combine into a larger one, one of them must be a function which takes the other as argument, yielding a new expression: for instance, in the maximally simple sentence *Elin smokes*, 'smokes' is understood as a function taking an individual as input and yielding a truth-value as output, ie. 'true' if Elin is in the set of smokers, and false otherwise; 'Elin' is taken to denote an individual.

The second element, $\gamma$, expresses the semantic *type* of the object $\varphi$ and can be viewed as a way of representing the kind of function that it is, which in turn is understood in terms of the sorts of arguments that it takes. Type theory is used for this purpose. Here, the type of a function is determined by its input and output, and in the simplest case are constructed recursively from the elements *e* ('individuals') and *t* ('truth-values') and functions from one to the other (written '$<\alpha, \beta>$' for a function from α-typed objects to β-typed objects). The denotation of 'smokes', written [[*smokes*]], for instance, is a function from individuals to truth-values, and so written $<e, t>$; 'Elin' is an individual and so [[*Elin*]] is of type *e*. A fuller set of types can be found in Figure 1.

1. $[[Elin]] = elin : e$
2. $[[smokes]] = \lambda x[smokes(x)] : <e, t>$

Note that, for any function, the argument it takes must correspond for its input type for function application to take place; for natural language, that means that when two words combine, one must be the right type to be input to the other, or a meaning for the complex expression will fail to be obtained.

With this background, we can start to see the problem that arises with universal transformations: in many cases, text transformation will result in strings of words that fail to denote expressions that can combine, because the expressions will fail to have the right types. Consider, for example, the sentence *Elin smokes and drinks*, and suppose that 'and' requires both expressions adjacent to it to have the identical type (here: $<e, t>$). But now suppose we substitute 'Elin' for 'drinks', yielding *Drinks smokes and Elin*: 'Elin' is of type *e*, and so the requirement of 'and' is not satisfied, and the semantic derivation will fail. The problem of universal text transformation is, in a nutshell, the problem of finding a way to assign types to lexical items in transformed texts that makes them interpretable in the semantic system. As we will see shortly, the way in which we do so has the potential for many unexpected and interesting results, and the further potential to produce a new space for literary (and other artistic) exploration.

| Type | Category | Examples |
|---|---|---|
| *e* | N | Tabitha, Elis |
| *t* | S | ‘I like hazelnuts’, ‘You never shut up’ |
| <*e*, *t*> | N, Adj, V (intransitive) | wheatgrass, puzzling, masturbate |
| <*e*, <*e*, *t*>> | V (transitive), P | harvest, towards |
| <*e*, <*e*, <*e*, *t*>>> | V (ditransitive) | introduce, give |
| <<*e*, *t*>, <*e*, *t*>> | Adv | frenziedly, sadly |
| <*t*, <*t*, *t*>> | Conj | and, or |
| <<*e*, *t*>, <<*e*, *t*>, *t*>> | *D* | every, some |

Fig. 1. Attested types in natural language.

## 3. System

The most obvious way to universalize interpretation is to allow expressions to have their standard denotations and to define mappings from them to expressions of other types. Assuming the set of possible types used in natural language is finite, we then will have a procedure for interpreting any term in any position. This simple strategy extends standard work on type-shifting in linguistics (e.g. Hendriks 1993; Winter 2002), with the difference that, instead of using type-shifters to ‘normalize’ semantic parsetrees by mapping nonconforming elements of them in a way that yields the expected denotation, we are instead starting with nonstandard syntactic configurations (or, at least, configurations in which unexpected elements comprise the leaves of a syntactic tree derived by familiar grammars) and transforming them in such a way that they yield an interpretation which might be unexpected or even incomprehensible (though semantically or logically coherent).

Concretizing this method requires starting with a set of semantic types and providing a system for transforming each of them into all the others. Since our interest here is text transformations, we need only consider the set of types attested in natural languages. Figure 1 lists the types that will be addressed in the work described here.[2]

For the project, it will suffice to have rules which can transform each element into elements of one other type. We need not write rules transmuting each type into all other types, as chains of type-shifting can be introduced. Some of the necessary rules already can be found in published work, and we will make free use of these here. The others – those not needed for practical linguistic applications, and so not addressed in that literature – must be defined separately.

The strategy of this section will be to use interpretations close to some familiar ones found in natural language, and to use the simplest possible methods:

2. This list is not completely exhaustive: it ignores several factors, for instance the complexity of the adverbial system (which admits several other types, e.g. sentential adverbs) and the existence of not-at-issue types such as those used for expressive content. Extensions to these domains are, however, straightforwardly available.

heavy use of identity functions and indexical substitutions. The last section of this work will explore more ambitious and wilder possibilities. Let us start with the simplest types, *e* and *t*. (3) is a rule which maps type *e* objects – proper names – to the sets of individuals named by that term. The existing literature includes many rules useful for going back and forth from different interpretations of nominals, which are necessary for the semantic parsing of certain linguistic phenomena; (4) is one such rule, mapping The strategy of this section will be to use interpretations close to some familiar ones found in natural language, and to use the simplest possible methods: heavy use of identity functions and indexical substitutions. The last section of this work will explore more ambitious and wilder possibilities. Let us start with the simplest types, *e* and *t*. (3) is a rule which maps type e objects – proper names – to the sets of individuals named by that term. The existing literature includes many rules useful for going back and forth from different interpretations of nominals, which are necessary for the semantic parsing of certain linguistic phenomena; (4) is one such rule, mapping properties to their associated definite descriptions.[3]

3. The below is only an exemplar selected from the domain of possible rules for each case: for the current project, it is enough to be able to derive interpretations, as opposed to explicitly making available all possible interpretations. Again, other rules can be selected from the provided sources if desired, or other kinds of interpretations, for instance nominalizations of verbs or adjectives (*littering, blueness*) instead of the $\iota$ rule (Chierchia and Turner, 1988; Chierchia, 1998). See the last section for more discussion and alternatives.

3. $[[name]]=\lambda x\lambda y[named(x, y)]$ : $<e, <e, t>>$
   Example: $[[name]]( [[Tabitha]])=\lambda x[\lambda y.named(x, y)](t) = \lambda y[named(Tabitha, y)]$
4. $[[\iota]]=\lambda P[\iota x[P(x)]]$ : $<<e, t>, e>$ (Partee, 1987)
   Example: $[[\iota]]( [[mongoose]])=\lambda P[\iota x[P(x)]](\lambda x[mongoose(x)]) = \iota x[mongoose(x)]$

The strategy in (3) will not work (or not straightforwardly) for adding arguments to existing types in general. Here we will make use of indexical elements instead: the standard indexicals tied to the context of utterance familiar from the work of Kaplan (1989). Adding arguments will amount to the insertion of variables or, in some cases, indexical elements; removing arguments will amount to the insertion of indexical terms which saturate the argument positions in question. (5) shifts one-place (intransitive) predicates to two-place (transitive) ones by introducing an additional argument place associated with a causation. (6) shifts two-place predicates to three-place ones by adding an argument place for the time at which the predication holds.

5. $[[cause]]=\lambda P\lambda y\lambda x[cause(x, P(y))]$ : $<<e, t>, <e, <e, t>>>$
   Example: $[[cause]]( [[sleep]])= \lambda P\lambda y\lambda x[cause(x, P(y))](\lambda z[sleep(z)]) = \lambda y\lambda x[cause(x, (sleep(y))]$
6. $[[at]]=\lambda R\lambda z\lambda y\lambda x.R(y)(x))$ at $z$ : $<<e, <e, t>>, <e, <e, <e, t>>>>$
   Example: $[[at]]( [[kiss]])= \lambda R\lambda z\lambda y\lambda x[R(y(x)$ at $z](\lambda y'\lambda x'[kiss(x', y')]) = \lambda z\lambda y\lambda x[kiss(x, y)$ at $z]$

For the lowering side of these, we simply saturate existing positions with indexical elements. (7) maps three-place predicates to two-place ones; (8) saturates an argument position of a two-place predicate. Both of these mappings are managed via the insertion of an indexical element *this*, the value of which is selected from available contextual elements as usual with what amounts to a free variable. Further discussion of the role of pragmatic reasoning in systems like this will be deferred to the final section.

7. $[[trans]] = \lambda R \lambda y \lambda x[R(this)(y)(x)]$ : $<<e, <e, <e, t>>>, <e, <e, t>>>$
   Example: $[[trans]]([[give]]) = \lambda R \lambda y \lambda x[R(this)(y)(x)](\lambda z' \lambda y' \lambda x'[give(x', y', z')]) = \lambda y \lambda x[give(x, y, this)])$
8. $[[intrans]] = \lambda R \lambda x[R(this)(x)]$ : $<<e, <e, t>>, <e, t>>$
   Example: $[[intrans]]([[kiss]]) = \lambda R \lambda x[R(this)(x)](\lambda y' \lambda x'[kiss(x', y')]) = \lambda x[kiss(x, this)$

Now we come to rules which have little use in empirical linguistics. The first rules introduced above are relatively commonly used; the second set can in principle be useful for things like causative alternations; the third set, while nonstandard, correspond to cases where an argument is present but unstated. The rules which follow are needed to ensure the interpretability of all strings, but result in meanings which don't really correspond to phenomena found in ordinary language. This is as desired: we are not especially interested here in 'sensible' semantics, but rather in the possibilities stemming from universal interpretation.

(9) maps adverbial denotations to one-place predicates. Here we could make use of a simple identity function, but for the project of textual substitutions and transformations, it is more interesting to allow the mapping to pick up something else from the text which is then modified by the adverbial meaning. This amounts to property anaphora, which is something frequently found in natural language (Asher, 1993); we could make use of dynamic tools, but here instead we simply allow the type-shifter to pick up a predicate from the discourse context.[4] The corresponding 'lift' is given in (10).

4. In the example in (9), the predicate is 'dynamic', which is in the discourse context because of its presence in the sentence to which this footnote is appended.

9. $[[existadv]]$=, where $Q \in C$, $\lambda P \lambda x[P(Q)(x)]$ : $<<<e, t>, <e, t>>, <e, t>>$
   Example: $[[existadv]]([[slowly]]) = \lambda P \lambda x[P(\lambda y[dynamic(y)])(x)](\lambda P \lambda y(slowly(P(y)))) = \lambda x[slowly(\lambda y[dynamic(y)])(x)]$
10. $[[inadv]] = \lambda P \lambda Q[Q(P)]$ : $<<e, t>, <<e, t>, <e, t>>>$
    Example: $[[inadv]]([[bitter]]) = \lambda P \lambda Q[Q(P)](\lambda y[bitter(y)]) = \lambda Q[Q(\lambda x[bitter(x)]]$

We now need rules which allow the two simplest types to alternate with each other. (11) takes type *t* objects – sentence denotations – into predicates, which

5. This transformation is by way of a proof of concept. A more contentful version might relativize the proposition to a source or to a judge parameter.

can then be lowered to type *e*;[5] (12) takes individuals into their corresponding statements of self-identity.

11. $[[tet]] = \lambda p \lambda x[p] : \langle t, \langle e, t\rangle\rangle$
Example: $[[tet]]([[the\ chips\ are\ old]]) = \lambda p \lambda x[p](old(chips)) = \lambda x[old(chips))]$

12. $[[et]] = \lambda x[x = x] : \langle e, t\rangle$
Example: $[[et]]([[tabitha]]) = \lambda x[x = x](t) = (t = t)$

The final two sets of rules needed are where things get downright strange, from the perspective of ordinary natural language interpretation. Here, we need to map conjunctions to other kinds of semantic objects, and produce and eliminate determiner meanings. This sort of operation is very much not a thing in the standard semantics of natural language: after all, what would it even mean for *blue* to have a quantificational meaning like *every*, or for *and* to predicate something of *Idis*, much less for *almond* to have a meaning which conjoins propositions? One set of possible answers to these questions follow, starting with the conjunctive case.

In the case of mappings involving conjunction, the 'lowering' direction is simple: we simply map the conjunction to a proposition, which can then in turn be fed back into the rule system to yield whatever type is required. The needed rule is given in (13). There we again make use of the discourse context in order to maintain the aesthetic of substitution/transformation. Consequently the mapping picks up the truth value of the previous discourse segment. To do this, an auxiliary definition is required: let the meaning of the text have the form $S_1, \ldots, S_n$ for discourse segments $1, \ldots, n$, and let the value of the sentence currently under interpretation be *i*, so its semantic value is $S_i$. We then map the conjunction to $S_{i-1}$, the value of the previous sentence. For mappings from predicates into conjunctions, it is of course possible to simply choose a conjunction – *and, if, or,* etc. – and map all predicates into it; here, however, we have chosen to incorporate all of the above and simultaneously use elements from each of the conjunctions mentioned. In (14), the predicate *PC* maps predicates *P* to conjunctive meanings, yielding the easily satisfied *or* if something in the discourse context satisfies *P*, but the more stringent conditions imposed by *and* otherwise. This definition has the additional advantage of retaining aspects of the meaning of the original, lifted predicate.

13. $[[ctop]] = \lambda C[S_{i-1}] : \langle\langle t, \langle t, t\rangle\rangle, t\rangle$
Example: $[[ctop]]([[or]]) = \lambda C[S_{i-q}](\lambda p \lambda q[p + q \geq 1]) = S_{i-1}$

14. $[[predcon]] =$
$\lambda P[PC(P)] : \langle\langle e, t\rangle, \langle t, \langle t, t\rangle\rangle\rangle$, where $PC(P) =_{def} \begin{cases} \lambda p \lambda q[p + q \geq 1] \text{ if } \\ \quad \exists x \in C[P(x)] \\ \lambda p \lambda q[p = q = 1] \text{ else} \end{cases}$
Example: $[[predcon]]([[vitamin]]) = \lambda P[PC(P)](\lambda x[vitamin(x)]) = PC(\lambda x[vitamin(x)])$

Now only the quantifier case remains. For the ‘raising’ case, the question is what quantificational force should be assigned. We define two distinct mappings here and allow them to be selected by context: this strategy is similar to the use of indexicals above. Other interpretations are of course possible. The ‘lowering’ case (16) picks out sets in which the quantifier properly applies to that set and some additional predicate, where both are available in the discourse context: this condition is not difficult to satisfy and thus is often also a place where pragmatic uncertainty enters the picture.

15. Predicate to quantifier.
    1. $[[predall]] = \lambda P' \lambda P \lambda Q[\forall x[P(x) \wedge P'(x) \rightarrow Q(x)] : \langle\langle e, t\rangle, \langle\langle e, t\rangle, \langle\langle e, t\rangle, t\rangle\rangle\rangle$
       Example: $[[predall]]([[blue]]) = \lambda P' \lambda P \lambda Q[\forall x[P(x) \wedge P'(x) \rightarrow Q(x)](\lambda x[blue(x)]) = \lambda P \lambda Q[\forall x[P(x) \wedge blue(x) \rightarrow Q(x)]$
    2. $[[predsome]] = \lambda P' \lambda P \lambda Q[\exists x[P(x) \wedge P'(x) \wedge Q(x)] : \langle\langle e, t\rangle, \langle\langle e, t\rangle, \langle\langle e, t\rangle, t\rangle\rangle\rangle$
       Example: $[[predsome]]([[blue]]) = \lambda P' \lambda P \lambda Q[\exists x[P(x) \wedge P'(x) \wedge Q(x)](\lambda x[blue(x)]) = \lambda P \lambda Q[\exists x[P(x) \wedge blue(x) \wedge Q(x)]$
16. $[[quantpred]] = \lambda Q \lambda x[P(x)]$ s.t. $\exists Q \in CQ(P)(Q)] \wedge P \in C : \langle\langle\langle e, t\rangle, \langle\langle e, t\rangle, t\rangle\rangle, \langle e, t\rangle\rangle$
    Example: $[[quantpred]]([[every]]) = \lambda Q \lambda x[P(x)](\lambda P \lambda Q \forall x[P(x) \rightarrow Q(x)] = \lambda x[P(x)]$ for $P$ s.t. $\forall y[P(y) \rightarrow Q(y)]$

With this, a system is in place to interpret any substitution of textual elements. Its overall form is shown in Figure 2. As is clear from the diagram, the type $\langle e, t\rangle$ is central to the system, but there is a path from any available type to every other, though it is sometimes circuitous.

The next sections show how it applies to the systematic replacement of terms in a particular text and situate the system in a larger artistic project involving notions of translation and constraint.

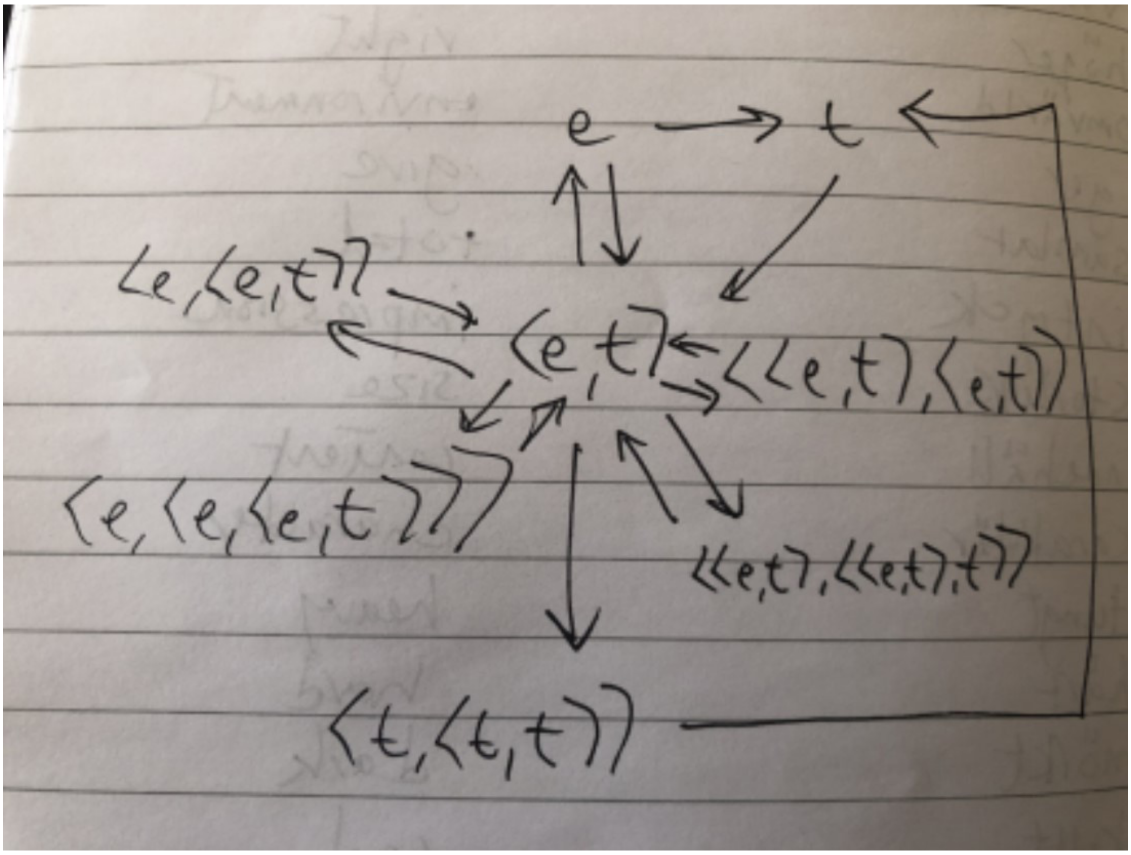



Fig. 2. Overall form of the type-shifting system for universal interpretation.

## 4. Realization

Let us now see how this system applies to a particular text. §3.1 indicates the text to be transformed, and the following two subsections show how the transformations work and their results. Along the way we also see the way in which the system produces choice points in the production of a semantic representation which give the reader agency in the interpretative process.

### 4.1 Source

The active reading method proposed here, consisting of textual substitutions and interpositioning, will be carried out twice on the following source text.[6] The method will first be applied in such a way that only items of similar type are substituted for one another. In the second iteration, the substitutions will be freer, yielding a wilder new text. In the final case, logical representations of some sentences of the text will be provided: no such representations are given for the other texts, since only in the third text will the need to introduce methods to interpret text completely freely arise. As we will see, this results in meanings as wild as the form of the new text itself.

6. This text was taken from https://en.wikipedia.org/wiki/Sailing_stones (April 20, 2020).

The first documented account of the sliding rock phenomenon dates to 1915, when a prospector named Joseph Crook from Fallon, Nevada, visited the Racetrack Playa site. In the following years, the Racetrack sparked interest from geologists Jim McAllister and Allen Agnew, who mapped the bedrock of the area in 1948 and published the earliest report about the sliding rocks in a Geologic Society of America Bulletin. Their publication gave a brief description of the playa furrows and scrapers, stating that no exact measurements had been taken and suggesting that furrows were the remnants of scrapers propelled by strong gusts of wind – such as the variable winds that produce dust-devils – over a muddy playa floor. Controversy over the origin of the furrows prompted the search for the occurrence of similar phenomena at other locations. Such a location was found at Little Bonnie Claire Playa in Nye County, Nevada, and the phenomenon was studied there, as well.

## 4.2 Transformation

A first transformation of the text is reproduced in this section. We have here applied three operations in limited number: these are listed below. We restrict the use of these transformations to ones which do not affect the syntactic or semantic structure of the text substantially, which in essence amounts to substitutions within similar syntactic categories. As we will see, this drastically limits the sort of substitutions that can be carried out, and the degree to which changes in the text are possible.

1. Intersubstitution of words within the text (limit: 5 substitutions). Two points: when substitution requires changes in grammar – pluralization, agreement, etc. – the needed changes are also made; substitution can apply to multiple forms of the same root (e.g. *published, publication*).
2. Deletion of words (limit: 2 deletions). Again, grammatical changes are allowed.
3. Systematic and deliberate mis-resolution of ambiguous words together with restatement into unambiguous forms.

The specific alterations made here are as follows; in the text itself, substitutions and deletions made are indicated with boldface.

1. Substitutions:
   (a) phenomenon ⟷ wind
   (b) crook ⟷ prospector
   (c) area ⟷ origin

(d) play ⟷ slide
(e) America ⟷ Fallon

2. Deletions:
(a) Nevada
(b) rock

3. Misinterpretations:
(a) playa: The intended meaning is the Spanish *playa* 'beach', but we reinterpret as the English term and spell it out as 'player'.

The first documented account of the **playing**___ **wind** dates to 1915, when a **crook** named Joseph **Prospector** from **America** visited the Racetrack **Slider** site. In the following years, the Racetrack sparked interest from geologists Jim McAllister and Allen Agnew, who mapped the bed___ of the **origin** in 1948 and published the earliest report about the **playing**___ in a Geologic Society of **Fallon** Bulletin. Their publication gave a brief description of the **slider** furrows and scrapers, stating that no exact measurements had been taken and suggesting that furrows were the remnants of scrapers propelled by strong gusts of **phenomena** – such as the variable **phenomena** that produce dust-devils – over a muddy **slider** floor. Controversy over the **area** of the furrows prompted the search for the occurrence of similar **winds** at other locations. Such a location was found at Little Bonnie Claire **Slider** in Nye County and the **wind** was studied there, as well.

The sense of the text has changed substantially, not just in that it is no longer about sailing stones but rather about some sort of wind, but also in location: the setting is no longer the USA, but somewhere else. It is a bit harder to make sense of than the original and some of it looks silly, but the changes are not extremely substantial. This is to be expected given the limitations imposed above, namely that we required ourselves to respect the normal syntax and semantics of English; and, indeed, the sentences comprising the resulting text can easily be interpreted using standard compositional methods (Heim and Kratzer, 1998) augmented with mechanisms for parenthetical expressions (e.g. Potts 2005). The entire text itself is also easily modeled in a dynamic setting for text interpretation (Groenendijk and Stokhof, 1991; Muskens et al., 1997). Thus, for this less ambitious version of a substitutional project, the sort of rules introduced in section 2 aren't required; but the result is not as deep or interesting as one might hope for given the possibility of universal substitution. We thus see that this simple style of substitution is open to the same critique I leveled against the N+7 transformation above: excessive conservatism.

## 4.3 Retransformation

We now take the already altered text from the previous section and apply further transformations to it. The types of transformations and the number which we are allowed to apply remain constant, but this time we impose no constraint on respecting standard syntactic or semantic structures, or type identity of the substituted elements. Again, some grammatical smoothing will be carried out when tweaking the text makes the morphology odd, e.g. for pluralization and agreement; but, given the setting, we will not make alterations in category. The result will be a text that is much wilder than the first transformed version. The specific alterations made are as follows; in the text, they are italicized (the boldface from the previous transformations also remains).

1. Substitutions:
   (a) 1915 ⟷ geologic
   (b) muddy ⟷ no
   (c) a ⟷ variable
   (d) Allen ⟷ taken
   (e) and ⟷ furrow

2. Deletions:
   (a) exact
   (b) measurements

3. Misinterpretations:
   (a) variable: in the original text, the intended sense is *varying/changeable*, but we will interpret it as in *mathematical variable*, and so as a nominal of type <*e, t*>.

The first documented account of the **playing** ___ **wind** dates to *geologic*, when *variable* **crook** named Joseph **Prospector** from **America** visited the Racetrack **Slider** site. In the following years, the Racetrack sparked interest from geologists Jim McAllister *furrow taken* Agnew, who mapped the bed___ of the origin in 1948 *furrow* published the earliest report about the **playing**___ in *variable 1915* Society of **Fallon** Bulletin. Their publication gave variable brief description of the **slider** ands *furrow* scrapers, stating that *muddy* ___ ___ had been *Allen furrow* suggesting that *ands* were the remnants of scrapers propelled by strong gusts of **phenomena** – such as the *a* **phenomena** that produce dust-devils – over *variable* no **slider** floor. Controversy over the **area** of the *ands* prompted the search for the occurrence of similar **winds** at other locations. Such *variable* location was found at Little Bonnie Claire **Slider** in Nye County *furrow* the wind was studied there, as well.

This text is very different from the original, and it is quite hard to interpret. But, with the machinery of section 2, an interpretation can be assigned, even to those cases where the structure is very messy. We show this by providing logical forms for several sentences (or clauses) in this variation of the source text. For composition, we assume the following: (i) composition of elements occurs via either functional application or the predicate modification of Heim and Kratzer (1998); (ii) when substituting terms, the sense is substituted but (crucially) the type of the leaf of the tree remains constant, so composition requires shifting each lexical term into the semantic type appropriate for the position (meaning, for instance, that because *variable* was substituted for *a*, the semantic type of *variable* in all positions where it now appears is that of a generalized quantifier); (iii) only in cases of deletion can syntactic reanalysis occur, meaning that only there do we end up with new trees and thus possibly unchanged semantic types for the elements to be composed. All of these decisions are of course changeable, and are made here mainly for the purpose of illustrating the aesthetic of the formal system. In practice, as with other kinds of reading (active and passive), the reader will be free to choose their own interpretation.

To illustrate how things go, we will give interpretations for two (simplified) sentences from the new text. The main point of this is to show how the system is able to derive meanings for expressions that are misplaced from a type-theoretic perspective – particularly expressions which move strongly across categories, like the shift from nominal to determiner – and how reanalysis resulting from deletion can yield new interpretations. The sentences have been chosen to this end.

The first sentence is (17), one of the simpler sentences in the text but one that exhibits several of the phenomena of interest to us here. The substitution of *variable* for *a* means that *variable* must be given a generalized quantifier type, and the substitution of *furrow* for and means that *furrow* here must be interpreted as a (logical) connective. Applying the rules for these operations – (15) in the first case, and (14) in the second – gives the meanings in (18) and (19) for these terms. Each of these cases has a special feature: in the case of $[[variable_{gq}]]$, universal and existential meanings were both available, but we have allowed context to select the existential meaning, and for $[[furrow_{con}]]$, a strong conjunction was chosen because the discourse context failed to make available any object satisfying *furrow* in its literal sense. The meaning of (17) is then given in (20); this is of course absurd and impossible to satisfy in any model which closely corresponds to the structure of our world, since no location is also a mathematical variable here.

17. Variable location was found at Little Bonnie Claire Slider furrow the wind was studied. (S5)
18. $[[variable_{gq}]] = \lambda P \lambda Q[\exists x[P(x) \wedge variable(x) \wedge Q(x)]$
19. $[[furrow_{con}]] = \lambda p \lambda q[p = q = 1]$

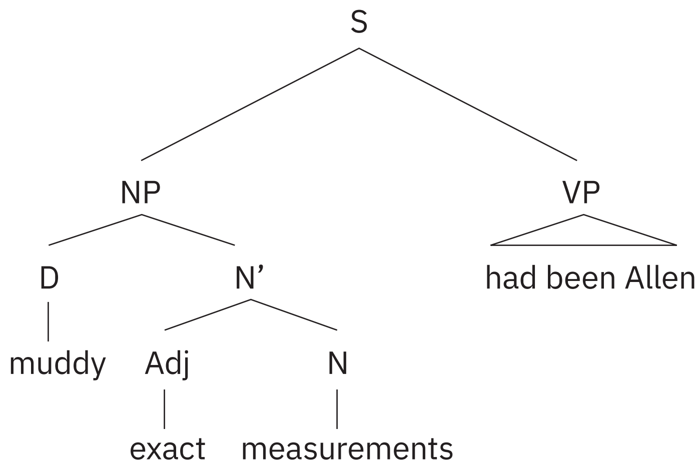
20. $\exists x[location(x) \land variable(x) \land found\_at(x, lbcs) \land \iota x[wind(y) \land studied(y)]]$
'There is a location which is a mathematical variable and is found at Little Bonnie Claire Slider and the wind was studied.'

Turning to (21), several new and interesting issues arise: the nominal interpretation of *and*, the predicative interpretations of *Allen* and of *no*, and, most interestingly perhaps, what to do with *muddy*, which has been left in a mysterious situation, lying in a determiner position but which fails to form a constituent with any other lexical terms due to the deletion of the words following it. The first three issues are easily addressed in the same way as just seen for (17), with the sole caveat that interpreting *and* as a nominal requires chaining of two rules: first (13), which alters the connective meaning to a simple truth-value 0 which can then be shifted to an <*e, t*> type by (11). We arrive at truth-value 0 because (13) instructs us to take the truth-value for the previous sentence, but, just as we saw immediately above, the use of *furrow* as a connective means that the connective has the semantics of *and*, which means that if any of the conjoined sentences is false, the whole sentence is, and the use of generalized quantifier *variable* in the place of publication – *variable 1915 Society of Fallon Bulletin* – means falsehood for this sentence, for nothing is both a bulletin and a mathematical variable, just as in the previous example. For the case of *no*, we require two predicates from the discourse context such that there is no overlap in their denotations: many such are available, but selecting [[*wind*]] and [[*geologist*]] works, and causes $[[no_{pred}]] = [[wind]]$ (or [[*geologist*]], but we have selected [[*wind*]] here). The results of all this are given in (22), (23), and (24).

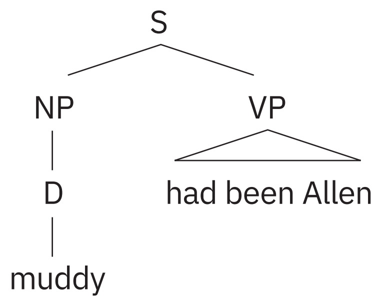
21. Their publication gave variable brief description of the slider ands furrow scrapers, stating that muddy had been Allen furrow ands were the remnants of scrapers propelled over variable no slider floor. (S3)
22. $[[and_{nom}]] = \lambda x[0]$
23. $[[allen_{pred}]] = \lambda x[named(allen, x)]$
24. $[[no_{pred}]] = \lambda x[wind(x)]$

The situation with *muddy* is more complicated and requires having a look at the syntax. The clause we must consider is the complement of *stating*, namely *muddy had been Allen*, which before deletion of 'exact measurements' had the following structure:[7]

7. This syntax is primitive, and syntacticians might find it shocking (especially how labeling works after deletion takes place), but we need not be too concerned about it because our aim here is only to characterize how semantic composition takes place in this kind of example.




After deletion takes place, the structure is as follows, assuming that categories remain constant and no covert elements are present (consonant with true deletion):




So in this situation, *muddy* should be given the type of a generalized quantifier as it is in a D position. This is straightforward using (15), yielding (25), in which the quantifier is given a universal interpretation.

25. $[[muddy_{gq}]] = \lambda P \lambda Q[\forall x[P(\mathrm{x}) \wedge muddy(x) \rightarrow Q(x)]$

But this won't give a proper denotation for the sentential complement, as its own complement is of type <*e, t*>: the output of composition will be type <<*e, t*>, *t*>, which will fail to be sensible. Here, then, we need to do a more standard kind of linguistic type-shifting, and massage the type of $[[muddy_{gq}]]$ into something suitable for composition with its complement in such a way that it yields a type *t* object. Fortunately, such an operation is already available. We need only map the generalized quantifier into a predicate and further lower that to something of type *e*. This mapping is carried out in two steps according to (16) and (4). In the first step, (16) applies to (25), which is a universal quantifier which qualifies its first argument with the predication *muddy*; since nothing in the discourse context is both (known to be) muddy and anything else, the antecedent is trivially satisfied and we can pick any predicate from the discourse context for the output. We choose [[*crook*]]; this is then mapped to an individual by (4), ultimately yielding (26).

26. $[[muddy_e]] = \iota x[crook(x)]$

With all this in hand, (21) can be given the semantic interpretation in (27). This interpretation is one that the reader would likely not arrive at without the aid of the semantic framework, and the unexpected ways in which the rules interact, as seen for instance with *muddy*, which would never have been interpreted as the property [[*crook*]] without the interaction of the rules which derived it: (25), (16) and (4).

27. $\exists x \exists y[publication(x) \wedge made(y, x) \wedge \exists z[brie\ f(z) \wedge part(z, x)$
$\wedge\ desc(z, \iota x'\forall y'[y' \subseteq x' \rightarrow \lambda y[0](x') \wedge slider(y) \vee scraper(y')])$
$\wedge variable(z) \wedge state(z, \iota z'[crook(z') \wedge named(allen, z')] \wedge \iota x''[\lambda z[0]$
$(x'') \wedge scraper\ remnant(x'') \wedge \exists y''[variable(y'') \wedge wind(y'')$
$\wedge slider(y'') \wedge floor(y'') \wedge propelled\_over(x'', y'')]])]]$
'There is a publication they made which contains a description of something all parts of which are either false or sliders or scrapers, and which is a mathematical variable; it also states that there is a crook named Allen and the existence of other things which are false and also scraper remnants which are propelled over a floor which is a slider and wind and a mathematical variable.'

This is very odd; but it is also a kind of poetry, with a kind of beauty. This meaning itself can be restated in other ways, for instance in free verse as in Figure 3. This text is entirely unexpected from the perspective of the original. This is one way to realize the aesthetic of textual substitution, and one way to use mathematical tools and constraints to make the process simultaneously transparent and opaque.

## 5. Variation

The goal of this work was to set out a system for the universal interpretation of textual transformations and substitutions irrespective of syntactic/semantic category. A sample system was provided in §2. The examples in the last section showed the power of the system: it can result in unexpected and strange changes in textual meaning, and ones that may bring out the meaning of the kinds of texts that result from cross-categorial substitutions in a more interesting way than simply trying to make sense of then 'manually' as the type-shifters interact in potentially unanticipated ways. The project of text transformation/substitution is part of a larger practice of constructing translations/mappings between media: texts, mathematical structures, spacetime, concepts, physical objects (McCready, 2020). The present work shows one way this practice can be carried out, and one way formalization can contribute to it. It is also a first example of artistic work in which mathematics is the medium rather than merely a technique or a place to draw inspiration, in the sense that the system itself is to be understood as the object of artistic practice (though in this case the full interest of the practice arises in conjunction with texts and substitution).

Fig. 3. Free verse translation of (27).

words on a page
available
to all
describe a thing:
complex, multifaceted
all of it false
or a tool for
sliding or scraping and
jointly
a variable
x or y or z

these words
claim more, claim
a presence:
dishonest Allen
and more presences
false things
remnants
vestiges of scrapers
moved
by exterior force
across a complex plane
a floor a variable a slider
wind

The results of the substitutions can be made more wild by further modifying the type-shifters themselves. In this initial version, we have mostly just used the discourse context, pragmatics, and a kind of reader-based choice function (ie.: the interpreter can pick whatever predicate strikes them as appropriate, as we did with [[$muddy_e$]]) above), but more randomized options are available too. One could assign each word in the text a position in a table of numbers in the way we already did for discourse segments and truth values, and then randomly generate numbers which induce substitutions, using dice or computational means. This kind of randomization can be built into the type-shifters, which will produce quite different sorts of transformed texts than the ones above. We expect that further experimentation will produce highly different results. More broadly, the current system suggests a new palette for experimentation on texts via mathematical methods which has the potential to open up interesting new domains for artistic practice.

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