Classifying Relationships

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Rick Szostak is professor of economics at the University of Alberta. The focus of his research is to facilitate interdisciplinarity. Knowledge organization is the dominant element in that research agenda, and he has authored two books and several articles that develop classifications of things studied, theories and methods applied, types of data, ethical perspectives, research practices, and now relationships among things. He has contributed to the Integrative Levels Classification and is developing the Basic Concepts Classification. He argues for the value of a classification grounded not in disciplines, but in the things we study and the relationships among these.

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ABSTRACT: This paper develops a classification of relationships among things, with many potential uses within information science. Unlike previous classifications of relationships, it is hoped that this classification will provide benefits that exceed the costs of application. The major theoretical innovation is to stress the importance of causal relationships, albeit not exclusively. The paper also stresses the advantages of using compounds of simpler terms: verbs compounded with other verbs, adverbs, or things. The classification builds upon a review of the previous literature and a broad inductive survey of potential sources in a recent article in this journal. The result is a classification that is both manageable in size and easy to apply and yet encompasses all of the relationships necessary for classifying documents or even ideas.

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All analysis of information for storage and of questions for effecting retrieval must be in terms of concepts and the relations between them—Farradane 1967, 297.

The cause-effect relation affects all aspects of our lives. It pervades our thinking and motivates our rational actions. Knowledge of cause and effect provides the basis for rational decision-making and problem-solving. It is important in all areas of science and technology. It can be argued that the ultimate goal of most research is to identify cause and effect—Khoo, Chan, and Niu 2002, 51.

1.0 Introduction

In a recent article in this journal (Szostak 2012), several principles for the development of a classification of the relationships between things were outlined. (There are also relationships among documents, and between documents and creators, that are critical to knowledge organization (see Green 2008) but these will not be addressed here.) These principles stressed the importance of compounding verbs with other verbs, things, or adverbs. That article also summarized an inductive survey of a variety of sources: a verb classification, a thesaurus, research on natural semantic metalanguage, and a couple of ontologies. This article applies those principles to the large set of relationships that were identified inductively.

Section 2 focuses on causal relationships, where "causal" is defined broadly to include any alleged influence that one thing might exert on another. My previous paper had stressed the importance of classifying these. Section 3 then develops a classification of non-causal relationships. The schedules of both causal and non-causal relationships turn out to be very manageable in size. Section 4 shows how the terms in the schedules can be combined to generate a very large set of relators. The concluding section 5 reviews the advantages of the classification for classificationist, classifier, and user.

2.0 The Classification of Causal Relationships

2.1 Combining Induction and Deduction

Induction is inherently a messy enterprise, and induction across distinct and large data sets especially so. But the path forward is clear. We take the terms identified by the inductive efforts of the previous paper and attempt to organize these into classes and subclasses. The deductive efforts of Farradane (1967) and Perrault (1994) give us some guidance as to how to proceed; it makes sense in particular to distinguish physical, biological, and intentional types of influence (at least). Once items have been grouped, we can then ask which groupings are likely to be of greatest importance to the classificationist and proceed to organize a classification accordingly.

As noted in the previous paper, one challenge of developing a classification of things and the relationships among them is that some terms (such as communication, perception) are often used as both things and relationships. While it would be possible in principle to distinguish these uses, and employ different terminology for each under the classification of things and the classification of relationships, the complexity-minimizing approach to classification would be to classify these (and indeed subclasses of perception and communication) in one place, but apply notational devices where possible to distinguish use-as-noun from use-as-verb. Since classifications of "things" are more well-developed, and we are seeking a manageable classification of relationships, it will generally be easier to treat such cases within the classification of things, but allow notationally for these to be utilized when classifying relationships. In what follows, we will focus on classifying relationships, but will note where certain relators could be placed within a classification of things.

Compound designation will be employed liberally in what follows. Indeed the strategy used by the author in organizing the inductive material was to first ask of each term whether it was really a compound of simpler terms—usually a pair of verbs or a verb and adverb or verb and thing, but sometimes more complex combinations. Note that it is always possible to give a simpler notation, if desired, to a commonly employed compound. Of course, some compounds are less obvious than others. Classificationists, classifiers, and especially users may often have recourse to the detailed classification or even thesauri in order to determine how a particular term was translated into a compound of simpler terms. Yet these compounds have important virtues beyond merely dramatically reducing the size of the schedules. They connect more complex relationships to simpler relationships. Users who know what they are looking for, but do not know the precise term for the complex relationship, can readily find what they wish. By drawing connections across related relationships, users may also often uncover connections of which they (and often anyone) were previously unaware. Last but not least, compounding facilitates the task of achieving precision in terminological definition (see below).

It should be stressed that the classification that is developed below is virtually exhaustive. All of the relators identified in the extensive works included in the inductive survey find a place in the classification, some as basic relators, most as compounds of these (and a minority are treated as things). In employing the classification, then, classificationist, classifier, and user will rarely, if ever, encounter a relationship that is not already addressed within the classification. And it is likely that any new relationships identified by scholars can be handled by some novel compound.

2.2 Some initial considerations

As the elements in this classification are listed below, it is often useful for purposes of clarification to indicate how some closely related concepts can be indicated using compounds. It is also very occasionally useful to speculate on whether the basic term included in the classification could itself have been viewed as a compound term. The first sort of commentary occurs in square brackets (with round brackets used within these to denote the simple terms being compounded), the second sort in round brackets.

Since most causal relators have opposites (move versus rest, cause versus do not cause), we can further reduce the complexity of our classification of relators by allowing the opposite of each (when appropriate) to be captured by some simple notation. These opposites are only rarely listed explicitly in what follows in order to conserve on space.

Some relators also have inverses—imply is the inverse of infer. It should generally be both possible and desirable to represent inverse meanings in precisely the same way. Since "A implied X to B" has the same meaning as "B inferred X from A," these should be represented by exactly the same notation in any classification. We will generally not bother to list inverses in what follows.

Since many relators refer to doing something again (most/all of the "re-"verbs do so, but there are oth-

ers), it is also useful in any classification of causal relators to provide some simple notation for "again" so that all such relators can be captured by "do X" combined with "again." Note that "again" is not itself a relator, but would be included in a list of temporal indicators within the classification of things.

Often, multiple terms are listed under the same entry below. In such cases, the author contends that the terms are synonymous enough that they can be treated together or that the differences which exist will always be clear in context. If grouping these terms together is thought to be undesirable in certain cases the general solution would be to employ compounding to further clarify the meaning of some of the terms.

It was suggested above that we could usefully organize our classification of causal relators into at least the three groupings of physical, biological, and intentional. It turns out that several relators can be applied in two or three of these groupings. This accords with the insight of Green (2008) that some relationships will be universal, but others domain-specific. It is useful to start with the more universal.

Relators will generally be listed in the past participle. It should be stressed, though, that they can generally be used as present participles as well: "A causing B" is similar to "A causes B" for most classificatory purposes. If distinctions needed to be made, this could be done through compounding with suitable temporal indicators. It should also be stressed that the linking terms "to" or "to be" can generally be omitted: "cause to lose" is "cause lose" and "cause to be free" is "cause free."

2.3 Relationships that transcend the types below

– Influencing or Causing in one or both directions

Note that there is no need to distinguish "cause object" from "cause event," as these will be clear in context.

Note also that in cases where we need to cope with the vague "X happened" this can be coded as just "X" or as "(something unidentified)(caused)(X)."

– Being or Experiencing or Occurring or Living as opposed to Dying or Not being. [Kill is (causes)(not)(being)]
– Moving versus Resting [Note that there are a host of "put" verbs that can be captured by compounding with intensity or location] [Carry is (move)(by hand)] [If it is found necessary to distinguish 'moving oneself' from 'moving other things' (impelling), the latter could be designated (cause)(move)]
– Creating or Making or Starting versus Destroying or Ending or Causing to disappear [Becoming is (Creating)(Self)] [Halt or Stop is (end)(moving)]
– Allowing or Facilitating versus Preventing or Restraining or Denying or Deterring or Disrupting [Note that these terms, though logically distinct from the previous set, should be somehow linked so that users searching for one will be alerted to the other.]
– Transforming or Changing. [When we say 'transforming X' we mean transforming of X. If we wish to designate 'transforming into Y' we need to combine "transform" and "create": (transforming)(creates)(Y). A process of transforming (or substituting) X into Y is (transform)(X)(creates)(Y). [Note that this also captures the inverse "Y derived from X."] [Particular kinds of transformation such as "sculpt" or "carve" or "blow glass" should be clear in the context of what is transformed into what. Nevertheless, further clarification is often desirable by identifying the type of transformation: heating, cutting, mixing, fire, etc.]
– Mixing or Combining versus Decomposing [Wet is (combine)(with)(water)] [Integrate is (combine)(insights)]
– Energizing or Arousing or Powering versus Calming (Note that this is distinct from transform or change.) [Rehabilitate is (energize)(again).]

We do not need a place for the generic word "process/procedure" for any "process for x" will be captured by "causes x" or "causes x to do y."

2.4 Physical influences

There are first a set of mechanical influences:

– Contacting or Hitting. (Note: This will generally be employed when the struck object does not move, and thus is distinguishable from "move.") [Crush is (strong) (hit)(change)(shape)] [Jab or Poke is (hit)(fast).] [Forge would be (heat)(and)(hit).]
– Cutting or Tearing or Breaking or Shearing. (Note: differences should be clear in context.) [Impale is (hit)(and)(cut).] [Bore or Drill is (cut)(holes).]
– Rubbing or Sanding or Causing friction [Sharpen is (rubbing)(causes)(pointed)] [Wear away is (rubbing)(changes)(shape)] [Erode is (climate)(causes friction)(change)(shape)]

– Straining or Tension
– Pressing or Compression [Roll might be rub and press]
– Circulating [This would capture one meaning of "Percolate" whereas the "filter" meaning would be captured by (separate)(by size)]
– Functioning (of a machine or tool) [Repair is (achieve)(functioning)(again)]
– Assembling versus Disassembling

There are then a set of non-mechanical influences:

– Heating versus Cooling (Distinct from, though may cause, energizing.) (Fire is a noun. Uses of fire as a verb can be captured by "cause fire" or "fire causes.")
– Cooking (Properly a subset of heating to at least some extent, but so common that it merits special treatment in any case.) [Notably, cooking is one of the few terms in our classification of relators where a set of subclasses which cannot readily be achieved through compounding is called for: basting, baking, broiling, toast, fry, poach, braise, barbecue, boil, tenderize, season, pickle, marinade, brown, stew, over/under-, roast, sauté [could be (fast)(fry)], simmer [could be (slow)(boil)], steep. sear, steam, raw] [There are also many terms that can be dealt with by compounding: salt is (cook)(with)(salt); brew could be (cook)(beer)]
– Pressuring [Sinter is (heat)(plus)(pressure)]
– Lighting
– Transmitting electric current [It is debatable how best to cope with subsidiary terms such as conduction, grounding, short circuit, or static electricity]
– Transmitting waves or rays [Refract is (change)(direction)(ray)]
– Magnetizing
– Transmitting nuclear radiation [X-ray testing is (evaluate)(by)]

Note that "React with chemically" may be captured adequately by (combine) (chemicals) (though I am less sure how to address nuclear reactions). More particular chemical processes may best be captured through links to a classification of chemical entities: "nucleate" is (create)(a nucleus); "flocculate" is (transforming) (creates)(small clumps). Note that neutralize has a specific chemical meaning distinct from the more general "cause to be ineffective."

Note that "collapse" is a vague term that at times means "end" and at times signals some sort of transformation that deserves to be specified.

Likewise various geological processes may be captured by links from relators such as "transform" combined with a classification of landforms and rock types (volcano, sediment etc.) Thus "foliate" is cause layers, and "fossilize" is transform flora or fauna into impressions in rock.

Finally, note that "State changes" (such as boiling or condensation) will be captured by linking "transforming" with gas, liquid, and/or solid. Shape changes and color changes will be captured by linking "transforming" to shapes or colors.

2.5 Biological influences

[Most all of these are in fact properly subsets of "transformation." The classificationist can debate how many deserve special treatment as opposed to treatment as kinds of transformation. If given special treatment, users searching by transformation in general or of particular types should be alerted to the existence of these classes.]

There are first a set of evolutionary influences:

– Evolving (It is likely useful to distinguish evolving within and across species) (It may also be useful to distinguish evolution at the level of genes versus organisms) [Breeding or eugenics would be selecting from evolution]
– Adapting (can be combined with climate, people etc.)
– Activating versus Suppressing of a gene

There are then a set of influences within the development of a particular organism. It makes sense here to distinguish (at least) plants from animals, since the developmental processes are so distinct. We start with plants:

– Reproducing (various types should be identified, perhaps through linked notation) [Fertilize in the narrow sense is cause reproduction, while "spread fertilizer" is facilitate reproduction of plants]
– Germinating
– Photosynthesis [Technically this is energizing through using sunlight in transforming carbon dioxide and water into nutrients. It deserves special treatment in the classification.]
– Development

Influences relevant to animals:

- Reproducing [asexual indicated through compound notation]
- Embryonic development
- Development [Overdevelopment is excessive development] [Developing into would be captured by linking to developmental forms]
- Functioning or metabolism [a general term for the normal function of an organ/tissue; note that dysfunction could then also be captured. Metabolism is properly the set of physical and chemical transformations that allow the organism to function] [Note that Khoo (1995) has a whole class of physiological reactions such as sweating which might best be treated as subclasses of function.]
- Discharging waste
- Shedding a body part [An important process for a subset of animals; it might nevertheless be captured by compounding rather than special treatment.]
- Cytolisis (The breakdown of cells by destruction of outer membrane)
- Affinity (as between antigen and antibody)
- Heterogenesis (as in caterpillar transformed into butterfly; a type of transformation that deserves special treatment)

It may or may not be desirable to provide special treatment for transformations such as Spoil or Ferment, rather than just identify these in terms of what is transformed into what.

Likewise, chemical processes within an organism may or may not deserve special treatment.

Several other biological terms encountered in our inductive survey are best treated as compounds. Digestion—and functions associated with other organs—could be captured by combining "transforming" or "energizing" with the stomach or other organ. Poisoning would combine ingesting with injury or death. Crystallizing is a form of transformation associated with shapes. Hydrolysis is likewise a transformation. Various precise terms for combination of (or creation/destruction of, or caused by) cells or genes etc. can be generated by compound terminology (likewise desensitizing). Faint is lose consciousness. Symbiosis is cooperation between species.

2.6 Intentional influences

We can start with some influences that operate at the individual level (these could, if desired, be divided into a set of influences internal to the individual, and a set of influences as the individual engages with the world):

- Perceiving or Detecting versus Ignoring [Particular types of perceiving can be captured by linking with the five senses or more detailed classifications of sounds, colors, shapes, and so on.] [An inverse term is "Indicating"]
- Feeling [While we could just say "cause emotion," it seems best to combine feeling with particular emotions]
- Desiring or Wanting
- Intending
- Believing
- Thinking or Reasoning or Supposing ["Thinking of" means study, analyze, interpret, or question. Several techniques for analyzing or inspecting (such as assaying, spectroscopy, thermal analysis, visual inspection) should be captured via links to different types of physical analysis] [Data processing is analysis by computer.]
- Classifying or Grouping [Might use for the more general "Listing" too] [Collating is grouping in sequence.]
- Evaluating or Judging or Reviewing [Counting or Inventorying could be evaluating number] [Measuring or Calculating is evaluating distance or mass or volume] [Appraise is evaluate price.] [Appreciate or Value is evaluate favourably] [Shop is evaluate to facilitate buying.]
- Deciding (about) [This could be "achieve decision-making," but that seems too convoluted.] [Commit is Decide to] [Define is decide a word or concept.] [Adjudicate is decide between; this concept needs to be linked to the related concept 'mediate' to facilitate user searches.]
- Selecting from [Summarize is select from text plus writing] [Discriminate is select from ethnic groups.] [Emphasize or Stress is select plus talk.] [Nominate is select candidate.]
- Performing or Working or Acting [Directing or Orchestrating is controlling performing] [Reenact is perform again (or perform plus remember might be more precise).] [Preview or Rehearse is perform before.]
- Practicing or Doing or Pursuing or Trying or Participating in
- Achieving or Preparing versus Failing
- Playing
- Using [Wearing might be captured by "using clothes"]

We can then list a set of influences that refer to some level of interaction between people:

– Demonstrating, Displaying, Exhibiting, or Presenting. [Broadcast would be associated with radio/TV.] [Manifesting would be an inverse term.]
– Controlling or Supervising [Administering or Managing might be distinguished by linking to organizations or processes rather than people.]
– Cooperating with versus Competing with [Attacking is competing associated with conflict.]
– Conflict
– Imitating or Pretending or Modeling
– Paying or Financing or Buying [Trade or Exchange is paying in both directions; Barter is trade without money] [Bequeath is (plan to) pay at death.] [Charity is paying non-profit] [Tax is paying government.] [Assess is evaluating taxes.] [Gamble is paying in/out associated with play.]
– Offering [Bid is offer price to buy.]
– Talking to, or Discussing, or Conversing [Advise versus Criticize can be captured by compounding with favorably/not] [Advocate versus Complain or Protest reflect intensity.] [Compliment is talk about individual favourably; Vouch or recommend is do so to others; Insult is opposite of compliment] [Guide is advise associated with direction. Whisper is talk with little loudness. Gossip is talk about people unfavourably. Describe is talk about something/one. Blather is talk too much. Leak is talk a secret. Warn is talk about danger. Consult is discuss a question. Inform is talk informative. Lobby is talk to change political institutions. Report is talk result.] [More contentiously, Ostracize/avoid is not talk to; Betray is talk secret; Rasp is talk associated with illness]
– Punishing [can be linked to prison, paying, talking, hitting] or Sanctioning.

Some works address spiritual or abstract processes not easily captured under the preceding subheadings:

– Proceeding to afterlife
– Reincarnation
– Gaining versus losing a soul.

Note that many intentional influences are best captured within the classification of things: the five types of perception, learning (including reading, writing, remembering), walking, various types of sexual activity.

2.7 Changes within a Phenomenon

We have focused above on the influence that one "thing" might exert on another "thing." Finally, but importantly, it is also necessary to classify certain "changes" that may occur within a particular phenomenon.

– Growth or Development versus Decline (Note that biological development is treated separately above because it involves qualitative changes of such a magnitude that organisms become different "things.")
– Fluctuations or Cycles or Alternation
– Stability of

2.8 Summing Up

We have ended up with 71 relators in our classification of causal relationships. These were organized into five types of relationship. The three most extensive of those types (physical, biological, and intentional) were further subdivided into two or three logical groupings, each of which contains a handful of entries. It should be easy within most notational schemes to indicate each of these seventy-one relators with just a couple of notational spaces. It might also be possible to indicate a subset of the most common of these (influence itself, maybe move as well) with only one notational space. In any case, it should then be feasible to combine two or even three relators to indicate a compound relationship while utilizing only a handful of notational spaces. We have thus succeeded in our goal of achieving a manageable yet extensive classification of causal relationships.

Yet the usability of that classification depends critically on the compounding that allowed us to keep the schedules above so short. Many examples of compounding were provided for clarificatory purposes above. A much longer set of compounds is provided below so that the reader can judge how accurately these compounds capture the meaning of the relator in question. Since many of these compounds also contain non-causal relators, it is useful to first introduce the set of these that was generated by the inductive effort pursued above.

Is this classification easy to use? The answer would seem to be that it is. The classes and subclasses are all defined in terms of words that have the same meaning here as in common parlance, and are some of the more unambiguous words used in everyday speech.

Is the classification perfect? Surely not. All scholarship is a conversation, and this is especially the case in information science. There are undoubtedly refinements that others can suggest. Yet I would argue that this paper has not only established that a classification

of (especially causal) relationships is feasible, but has shown what such a classification should look like.

3.0 The Classification of Non-Causal Relationships

As noted above, many non-causal relationships are already commonly identified within existing classifications. These are summarized here:

- And or With versus Without
- Or
- Of (history of computers) [May need to distinguish 'composed of' and the inverse "derivative of"]
- By/From (bibliographies by government agencies) [Perhaps the similar "With respect to" requires distinct notation] ["By" is a passive form of influence/causation. If more active influence is involved, the notation for influence (see above) should be pursued.]
- For (books for children) [It may be useful to distinguish "applied to"] [Coates (1988) notes that there is a big distinction between "machine for washing" in which "for" signals "of purpose" and "library for lending" in which "for" signals "mode of operation." Both can in turn be distinguished from uses of "of" to denote "[property] of."]
- In (usually applied to location and/or time period, but could also capture e.g., "corruption in politics") [Note that the distinct 'contained in' should be captured under a classification of directions]
- Of type [It is still useful to indicate "of type" notationally so that compounds such as 'map library' can be expressed without requiring that every type of library be indicated in the schedules.]
- Part of [Which would not need to be explicitly coded for in a logical hierarchical enumeration of 'things' which proceeded only in terms of "part of/type of" relationships. At present, many hierarchies contain non-logical "subdivisions," which actually involve relationships (see Cruse 2002, Pribbenow 2002).] [Note that "necessary part of" and "distinct part of" can be captured through compounding with the qualifiers "necessary" and "distinct."]
- Compared to
- Associated with or Accompanies
- About (talk about danger)
- From the perspective of (which can be linked to a classification of properties to capture Perrault's "positive," "indifferent," and "negative")

In addition to these commonly used relators, it would be desirable to develop:

- A set of locational and temporal relators: above, below, beside, east, west, north, south, before, after adds inside, outside, between, near, far, parallel, right, left, front, back, middle, during, toward, at, and away
- "Connected to" or "Attached to" versus "Separated from" or "Divided." [Apportion is divide in distinct parts.]
- As proportion of
- Composed of [inverse is Derivative of]
- Some simple notation to capture "not" or "opposite"
- The more/less/equal distinction, generally and with respect to size, length, and duration.
- Number/amount of; Degree of; As proportion of [Mazzocchi et al. (2007, 208) mentions grains of salt as another type of partitive relationship. They list five types of partitive relationship beyond type/kind and whole/part. Two are addressed here and in "Collection of" below. Shopping/Paying was addressed within causal relationships. Object/stuff (bike/steel) would best be captured by linked notation using the "for" relator. Area/place (desert/oasis) should be captured within a hierarchical classification of topography.]
- Collection of (Forest is "collection of trees" since forests are defined in terms of trees rather than the reverse.)

4.0 Compound Terms

The causal relators identified above can be combined with other causal relators or with non-causal relators to generate a vast array of further causal relators. In an important minority of cases, the compound causal relators below also include elements that are things. Though space naturally prevents the detailed articulation of a classification of things here (but see Szostak 2011a, 2011b), it can be noted here that the elements of a classification of things that are implicated most often are: directions and locations, shapes, colors, emotions, diseases, and temporal indicators; as well as a number of (adjective or adverb-like) qualities (including good/bad, more/fewer, fast/slow, effective/ineffective, and open/closed). Note that such things are essential to a classification of things as well as facilitating identification of these compounds.

It should be noted that these compounds were generated inductively. Indeed all of the terms identified in the inductive exercise conducted in this paper (or very close synonyms thereof) are addressed either in the classification above or in the compound terms below. The list below is thus likely fairly exhaustive of

the compound terms that a classifier would need to engage, though others can be generated as necessary. This last point is important not just because the author may have missed some important extant compounds but because (as with things) new compound relationships are created from time to time.

We can begin with some uses of (opposite). For example:

Disobedience is (opposite) (control) Note that "obey" is the inverse of "control."
Fails to communicate is (opposite) (talk)

We can then provide some combinations (primarily) of causal relators:

Absorb is (combining)(cause)(disappear). Solvent is (liquid)(causes)(Absorb)
Agree is (decide) (plus) (cooperate). Arbitrate/mediate is (supervise) (applied to) Agree. Negotiate is (attempt) Agree. Bargain is (attempt) Agree (price *or* wage)
Announce is (talk) (plus) (decide). Appoint is (talk) (plus) (select). Swear in is (ceremony) (associated with) (appoint *or* elect)
Assign is (select) (and) (control)
Authorize is (allow) (plus) (control)
Catalysis is (facilitating) (combining) (chemicals)
Commentate is (talk) (and) (evaluate)
Confess or Apologize is (talk) (about) (behaving) (unethically *or* illegally)
Control by incentives is (control) (by) (paying)
Convert [in the religious sense] is (cause) (change) (religion)
Customize is (desire) (applied to) (change)
Debate is (compete) (and) (talk)
Explore or Investigate is (perceive) (and) (think)
Fight is (compete) (plus) (hit)
Force is (control) (and) (move)
Identify or Authenticate is (decide) (X) (to be) (Y)
Imagine is (think) (plus) (desire)
Monitor is (observe) (and) (evaluate)
Persuasion is (control) (by) (talking). Dare adds (behave) (dangerous)
Pursuing is (desiring) (possess)
Request or Place order is (desire) (plus) (try).Fundraise adds (pay) (for) (charity *or* political party)
Share is (cooperate) (using)
State or Declare is (decide) (plus) (talk)
Typeset is (prepare) (for) (publishing). Proofread is (make) (text) (correct)

Combinations are possible with internal changes in particular:

Enhance is (cause) (growth) [Particular forms of this such as moving faster would be captured by more specific compounds]
Include is either (cause to be) (combined) or (cause to be) (contained in) [The ambiguity in the verb "include" is thus dealt with]
Lubricate is (reduce) (friction) [with oil?]
Maintaining or Upkeep is (cause) (stability) [cause to continue is an alternative here]
Reduce is (cause) (decline). Enlarge is cause increase
Stabilize is (cause to be) (stable)

Combinations with non-causal relationships are common:

Assemble is (create) (plus) (connected)
Attach is (cause) (to be connected)
Collect is (achieve) (collection)
Contact is (achieve) (connection). Visit is (move) (to contact)
Graft is (cause) (body parts) (to be connected)
Herd is (move) (a collection of) (animals *or* people)
Meeting is (a collection of) (people) (talking). Convene is (achieve) (meeting)
Release is (move to be) (not) (contained)
Searching is (looking) (for). Rummage is (looking) (for) (non-intensely). Scanning is (looking) (for) (quickly). Stalk or Hunt is ((looking) (for)) (with) (pursue). Groping is (looking) (for) (by touch). Scout is (looking) (for) (danger)

Combinations with things are even more common:

Adopt is (achieve) (parent-child relationship) (by) (legal documents)
Assimilate linguistically is (change language) if individual or (destroy) (language) if group. Translate is (change) (language) (of) (text). Encoding is translating for secrecy. Dub is change language on film
Attribute is (think) (X) (from) (text)
Careerism is (wanting) (promotion) (too much)
'Cause (something) to become the thing specified' (as in 'parcel' means 'to become a parcel') is (cause) (thing) (shape) (parcel)
Confining and Keeping are (controlling) (inside). Quarantine is confine for disease. Localize is confine to a locality

Classifying is (achieve) (classification) [distinct from (create) (classification)]
Compost is (transform) (waste) (into) (fertilizer)
Crossbreed is (cause) (fertility) (of type) ((X) (is associated with) (Y))
Date is (evaluate) (time period). Schedule is (decide) (time period.) Periodize is (evaluate) (by) (time period). Clock in is (demonstrate) (time period)
Discovering is (perceiving) (for the first time). Find oneself is discover oneself
Eating is (achieving) (nutrition). Grazing is (achieving) (nutrition) (of type) (grass)
Estimate is (perform) (approximate) (measurement)
Exercise is (move) (for) (exercising)
Filing or Submitting an application is (achieving) (form)
Flying is (moving) (by) (airplane) and Phoning is (talking) (by) (telephone)
Hire/fire is (create/destroy) (jobs) (for) (evaluation) [to distinguish fire from layoff] Quit is voluntary. Featherbed is (create) (too many) (jobs). Strike is (union) (temporarily) (decrease) (work) (associated with) (negotiation)
Ingratiate is (attempt) (friendship) [perhaps by complimenting]
Injure is (cause) (injury)
Intuit is (think) (with) (intuition).
Learn is (achieve) (learning)
Lecture is (talk) (a text). Teach is (talk) (associated with) (education). Coach is (talk) (sports) (associated with) (education)
Make noise (other than talk) is (cause) (noise)
Offend is (cause) (resentment). Harass is (cause) (resentment) (regularly)
Pack is (move) (inside)
Pamper is (perform) (too much) (kindness)
Pardon is (end) (a legal decision). Parole is (decrease) (a legal decision)
Pogrom is (attacking) (ethnic group)
Poll is (measure) (public opinion)
Possess is (control) (by) (ownership) [lose is end possession]
Pour is (move) (liquid)
Predict or Expect is (believe) (about) (future). Plan is (think) (about) (future). Surprise is (not) (expected)
Publishing is (creating) (text). Disseminating is (communicating) (text). Edit or Revise is (change) (text). Censorship is (preventing) (publication)
Recreate is (create) (again)
Rehearsing is (practicing) (play *or* song, etc.)
Remind is (cause) (other) (to remember). Record is (write) (to remember) [Note that remembering is classed as a thing (a human ability)]
Removing is (moving) (out) (and 'removing from; requires a causal chain: removing X from Y). Then, castrating could be moving out that which causes fertility in males]
Respond is (talk) (about) (after)
Restricting is (controlling) (scope *or* size) (reduction)
Schematize is (perform) (mapmaking) (of type) (conceptual)
Singing is (performing) (music)
Sink is (move) (down) (in liquid)
Solve is (achieve) (answer). Document is (achieve) (evidence)
Strangle is (cause) (injury *or* death) (of type) (respiration)
Synchronize is (cause) (time) (uniform)
Treat (a disease or illness) is (perform) (treatment). Surgery is this linked to cutting or moving
Trend setting is (changing) (fashion *or* values)
Wave, nod, wink, bow, salute, shrug, and other gestures, are (move) (of type) (talk) (associated with) (particular body parts)
Worry is (feel) (anxiety). Hurt is (cause) (pain)

Combinations are frequently made with adjectives/adverbs:

Accept is (decide) (favourably). Concede is accept the insight of another
Arrange is (cause) (arranged)
Brutalize is (cause to be) (brutal) or (act) (brutally) [we thus reduce the ambiguity in the word itself]
Cause to succeed is (cause) (X) (successful)
Clean is (cause) (clean)
Color is (cause) (color)
Compliment or Toast is (talk) (complimentary). Criticize is (talk) (critically). Advise is (talk) (supportively) [to cause improvement in something?] Espouse is (talk)) (about) (favorably). Support is (behave) (supportively)
Conspire is (cooperate) (secretly)
Damage is (cause) (damaged)
Decorate is (cause) (decorated)
Deform is (change) (shape) (bad)
Delay is (cause) (delayed)
Doubt is (think) (X) (mistaken) Misconstrue is (think) (mistaken)

Elaborate is (talk) (about) (more)
Embarrass financially is (cause) (poor)
Explode is (disassemble) (intensely). Detonate is (cause) (disassemble) (intensely)
Floating is (being) (on top of) (liquid)
Fortify is (cause) (safe). Protect or Defend is (facilitate) (safe). Defend oneself is (practice) (safe). Camouflage is (disguise) (for) (protect)
Guess or Suppose is (decide) (arbitrary)
Improve is (cause) (quality) (increase). Expedite is (cause) (quality) (increase) (associated with) (time)
Know or Understand or Assume is (think) (true) [despite NSM treating 'know' as a semantic primitive]
Maneuver is (move) (strategic)
Nag is (talk) (not) (complimentary) (regularly)
Open/close is (cause) (opened/closed)
Patronize is (talk) (complimentary) (false). Forge is (create) (false) (document). [I am unsure how best to treat "Trick," "Cheat," "Plant," and "Fraud." They may require causal chains (see below). Lure will be move by trick.]
Restore is (cause) (aesthetically pleasing) (again)
Suffer is (experience) (bad)
Suggest or Hint is (talk) (suggestively)
Sympathize is (understand) (feelings *or* beliefs)
Volunteering is (offering) (voluntary)

In particular, combinations are often made with adjectives/adverbs that signal intensity:

Focus is to (think *or* observe) (intensely)
Slam is (cause) (closed) (intensely)
Smash is (hit) (hard)
Yell is (talk) (intensely), whisper is (talk) (not) (intensely)

Note that some verbs can (only) be captured within causal chains:

Admit is (cause) (someone *or* group *or* state) (in) (some organization)
Alibi is (legal argument) (about) ((time) (and) (place))
Annex is (local government) (achieves) (land) (increase)
Assaying is (analyzing) (composition) (metals)
Audit is (evaluate) (payments) (in and out) (an organization)
Campaign is (attempt) ((control) (by) (talking)) (associated with) (election)
Chromatography is ((separation) (and) (analysis)) (of) (mixtures) (chemicals)
Citizenship is (individual) (associated with) (state). Naturalize is cause citizenship
Condemn building is (decide) (building) (unsafe)
Confiscate is ((control) (and) (move)) (change) (ownership)
Digitize is (change) (for) (computer) (read)
Disarmament is (decreasing) (economic output) (for) (military)
Evict is (move) (someone) (from) (home *or* office)
Extradite is (control) (immigration) (associated with) (trial)
Foist means (cause) (various things) (involuntarily)
Filibuster is (talk) (long time) (to prevent) (legislative decision)
Foreclose is (end) (investment) (of type) (loan) (for) (house)
Free is the causal chain (cause) (X) (not) (control) (Y)
Impeach is (cause) (individual) (lose job) (government executive)
Spectrometry is (measuring) (waves) (associated with) (radiation *or* absorption)
Tithe is (regular) (payments) (associated with) (religion)
Torture is (cause) (intense) (pain) (associated with) (punish *or* achieve information)
War is (states) ((moving) (and) (conflict)) [The best way to capture 'terrorism' has not yet been determined]
Zoning is (local government) (controls) (economic output) (associated with) (land)

5.0 Concluding Remarks

The challenge articulated at the start of this paper was to identify a classification of relationships that would provide benefits in classification greater than its costs in application. Though this calculation can only be performed precisely in user testing, there are several reasons to be confident that this challenge has been met:

- The schedules are of very manageable length.
- They are logically organized into a very manageable number of classes, each containing a handful of entries.
- The distinctions among classes are transparent.
- Yet these schedules and the compounds that can be generated from them capture all of the terms uncovered in a very broad inductive search for relators, as well as those implicated in previous deductive efforts.

– Thus all such terms can potentially be represented notationally within a mere handful of notational spaces.
– Though there has not been space to discuss this in detail, the classes in the schedules are likely to be interpreted in a very similar manner across disciplines and cultures (see Szostak 2011b).
– This classification of relationships thus potentially allows for the first time searches by 'type of relationship' across an entire universal classification.

The cost/benefit calculation can only improve as further refinements are made to the classification. In particular, it is likely that more precise compounding is possible for some of the compound terms listed above. It is even more likely that unnecessary detail has been provided in some places. Refinements can come both through an ongoing conversation within information science—readers are encouraged to suggest improvements—and through lessons learned as the classification is employed in practice (see below).

The classification of relationships has many possible uses, among them thesauri, ontologies, topic maps, and the semantic web. Yet the most obvious use of such a classification of relationships is in combination with a classification of "things" (phenomena) to generate a universal classification that relies heavily on (ideally post-coordinated) compounding of the relationships above—whether simple or compound themselves—with one or more things. Such a classification could free users (and classificationists and classifiers) from the disciplinary limitations of existing "universal" classifications (Leon Manifesto, Szostak 2008, 2011b), or at least serve as a useful supplement to these. Yet it will be flexible enough that it can be used to classify objects and ideas, as well as documents. Gnoli (2010) argues that the need to classify objects, not just documents, which is enhanced by digitization, can only be met by a phenomenon-based classification. This paper concurs, but suggests that the argument should be made in terms of a "phenomenon and relationship-based" classification. Indeed, such a (manageable and straightforward) classification may provide the key to an emerging challenge in information science—allowing users to simultaneously search across multiple databases that are available on the web, but tend to be classified in quite different ways (see Szostak 2011b; in a different context, Boteram and Hubrich (2010) argue that a subset of relationships is needed to provide interfaces between different classification systems).

Such a classification solves many problems identified within existing approaches to classification. Coates (1988, 60) stresses that we cannot, as Cutter had wished, rely exclusively on natural language for subject headings. We must be ready to move away from natural language when this generates ambiguity or limits recovery. A classification of relationships facilitates the use of compound headings in which a complex sentence can be reduced to its essence (which will often be "thing/relationship/thing"). Later (1988, 174) when Coates reviews the shortcomings of existing classification schemes he stresses, "makeshifts are resorted to in order to present an appearance of solving problems of subject interpolation." In other words, logical hierarchies are deviated from. Again, compound headings are the obvious solution (Cheti and Paradisi (2008) make a similar point).

Coates on that same page also argues that, ideally, it should be much easier to add new entries to a classification. Ranganathan had hoped that at some point a classification would become self-sustaining; that new subclasses would be generated in a straightforward manner by new combinations of existing subclasses. Dozens, if not hundreds, of new headings are added to the *Library of Congress Subject Headings* (*LCSH*) every week (Leong 2010). Moreover, internet communities often create naïve classifications because they are working on new topics for which formal classifications do not exist. Leong notes that, since *LCSH* (and other) subject headings were developed from literary warrant, they are ill-suited to using Boolean methods of combined search (or being compounded themselves). Only with the creation of a usable classification of relationships does it become possible to anticipate that complex new subjects can be readily rendered in terms of combinations of previously identified things and relationships.

Though the utility of a classification of relationships may be greatest in concert with a universal classification of things such as in the Integrative Levels Classification (ISKO Italia n.d.) or the Basic Concepts Classification (Szostak 2011a, 2011b), increased clarity can be provided by adding a classification of relationships to any existing classification system by coding works also for type of relationship. Szostak (2011b) discusses how the sort of classification discussed here could potentially serve as a supplement to an extant scheme such as the Dewey Decimal System. Broughton (2010) discusses more generally both the challenges and advantages of revising the Universal Decimal Classification schedules so that complex entries are treated as compounds of simpler terms.

Many/most of the terms used within existing classifications are compound terms (albeit expressed as if

they were simple terms) that contain references to both things and relationships (Szostak 2011b). Recourse to a standard classification of relationships would spare the classificationist from having to develop a new class for works that engaged a novel relationship among existing things; they could simply employ compound notation of things and relationships. Given that most works study how some things affect others in particular ways, reaping the advantages of compound terminology depends on the development of a classification of causal relationships.

Though the classification envisioned here may be a boon to both classificationists and classifiers, its greatest contribution would lie in facilitating the research efforts of scholars across all fields. Green (2008) cites both Davies and Swanson on how making connections across research involving causal and other relationships leads to the discovery of undiscovered public knowledge. That is, it is very difficult at present for researchers to find work by those in other fields that addresses similar relationships or thing-relationship combinations. Facilitating such searches inevitably enhances the rate of scholarly progress.

It is not just scholars that will benefit in this fashion. Users will often know that they want to find something like "stop dogs from attacking mail delivery person" and can readily access the relevant works if these are coded in terms of the relevant things (dogs) and relationships (attacking). The more adventurous or scholarly user may instead search across all instances of attacking (a task not facilitated within existing classifications) and find some previously unappreciated similarity or difference across the attacking behavior of different animals. Farradane (1967, 297) noted that "The relations between concepts often appear to be absent, but if more than one word is used in indexing or in a search there is clearly an implicit relationship in the mind of the indexer or questioner, and other relations possible between the words would lead to false drops." That is, failure to be explicit about relationships in a classification will often lead users astray. Green (2008) notes that, even when relationships are captured in a classification, the type of relationship is usually not specified; failed searches are thus common. She urges the specification of particular relationships.

Yet the advantages flow not just to those who have a good idea what they are looking for. One emerging area of research in information science is "exploratory search" and, in particular, how to use visual aids in guiding users who are exploring possibilities. A user that starts with some curiosity about "dogs" might be presented with a visual representation of the causal (or other) relationships which connect dogs with other phenomena. Causal links that have received the most attention might be emphasized, but the curious could readily follow links that have received less attention. Causal links to dogs could be distinguished by color from causal links from dogs. Other relationships, including hierarchical, could be represented in other colors or styles. One problem faced by researchers in this area is that documents are often not coded in terms of all of the relationships they wish to display. The use of compound notation in classifying would alleviate this problem.

Thesauri were mentioned above. "There are obvious advantages of a conceptually well structured classification when generating a thesaurus, since the clear identification of relationships allows some degree of mechanical handling of the process." (Broughton 2010, 275). Complex concepts can be broken into combinations of things and relationships (Szostak 2011b), both for the purposes of classification and for constructing thesauri, but only if a detailed classification of relationships is first generated.

Last but not least, the classification of relationships provided here may be of use in the development of upper level ontologies or semantic networks (which are, in turn, of increasing importance as digital technologies advance). These characteristically are each comprised both of things and relationships (and properties; Masolo et al. n.d., 43; Almeida, Souza, and Fonseca 2011). While precise definitions have not been attempted here of each entry in the schedules, it has been argued that this could be done. And then precise definitions of the much larger set of compound terms would follow. It is often argued that, while the set of "things" to be classified is infinite, the set of relationships is likely finite. This paper suggests that it is both finite and manageable.

It is useful to recall here the original cost/benefit challenge. The preceding paragraphs suggest both that users can benefit enormously from a classification of relationships and that classificationists and classifiers themselves will find, over time, that the cost of adding a classification of relationships to a classification of things is more than compensated by the myriad advantages of compounding relationships and things. Developers of thesauri, ontologies, and other systems can also benefit from this classification.

Of course, the information science literature contains many examples of suggestions for classifications that looked good on paper but failed in practice. We cannot be entirely confident of this classification un-

til it is tested by users. It is the author's intent to test this relationship—in combination with a classification of things (Szostak 2011a, 2011b)—in three ways: by seeing how well terms in existing universal classifications can be translated into the new "Basic Concepts Classification," by inviting other scholars to see how easily they can navigate the system, and by asking students to classify a diverse range of works in terms of this new system. The author hopes to report the results of these tests in a future issue of this journal.

These forms of user testing apply to only one—albeit perhaps the most obvious—use of the classification of relationships. Other scholars may usefully apply the classification for other purposes and report on its utility in these other uses. Multiple tests would be particularly useful in suggesting refinements to the classification. It could be that some classes in the classification are little used in some applications but much used in others. Indeed one value of a (nearly) exhaustive classification is that it can be expected to serve multiple functions. We should be wary of oversimplifying the classification (especially since it is already notationally compact) in response to a finding that some classes are rarely employed in a particular application.

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Corrections to 39 no. 2

On pages 75 and 77:

Table 2 & 3 in page 75, and Table 7 in page 77.
It should be corrected as follows.

<Table 2> Changes in the Usage of KDC by the Public Libraries

Classification System

Classification Systems	1986*		2009**	
	Oriental Books	Western Books	Oriental Books	Western Books
KDC	97.7% (84)	80.3% (49)	99.1% (541)	97.8% (534)
DDC	0% (0)	8.2% (5)	0.2% (1)	1.5% (8)
Others	2.3% (2)	11.5% (7)	0.7% (4)	0.7% (4)
Total Lib. Surveyed	86 libraries	61 libraries	546 libraries	

<Table 3> Changes in the Usage of University & College Libraries Using KDC

Classification System

Classification Systems	1986*		2001**		2007***		2010****	
	Oriental Books	Western Books	Oriental Books	Western Books	Oriental Books	Western Books	Oriental Books	Western Books
KDC	57.1% (56)	45.9% (45)	45.3% (68)	26.0% (39)	43.1% (72)	23.3% (39)	43.2% (73)	23.7% (40)
DDC	40.8% (40)	51.0% (50)	52.0% (78)	71.3% (107)	54.5% (91)	74.3% (124)	54.4% (92)	73.4% (124)
Others	2.0% (2)	3.0% (3)	2.7% (4)	2.7% (4)	2.4% (4)	2.4% (4)	2.4% (4)	2.9% (5)
Total Lib. Surveyed	98 libraries		150 libraries		167 libraries		169 libraries	

<Table 7> Mnemonics among Geographic Areas, Languages, History, Language and Literature in KDC[5)]

Tables		Main Classes		
Geographic Areas	Languages	Language (700)	Literature (800)	History (900)
-11 Korea	-1 Korean	710 Korean	810 Korean	911 Korea
-12 Japan	-2 Japanese	720 Japanese	820 Japanese	912 Japan
-13 China	-3 Chinese	730 Chinese	830 Chinese	913 China
-24 United Kingdom	-4 English	740 English	840 English	924 United Kingdom
-25 German	-5 German	750 German	850 German	925 German
-26 France	-6 French	760 French	860 French	926 France
-27 Spain	-7 Spanish	770 Spanish	870 Spanish	927 Spain
-28 Italy	-8 Italian	780 Italian	880 Italian	928 Italy

On page 142:

On page 142 Dr. Dahlberg's email was given incorrectly; it should be Ingetraut.Dahlberg@t-online.de