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Conceptual combination: extension and intension.

Commentary on Aerts, Gabora and Sozzo.

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Abstract

Aerts et al. provide a valuable model to capture the interactive nature of conceptual combination in conjunctions and disjunctions. The commentary provides a brief review of the interpretation of these interactions that has been offered in the literature, and argues for a closer link between the more traditional account in terms of concept intensions, and the parameters that emerge from the fitting of the Quantum Probability model.

1. Introduction: Prototypes and their compositionality

The issue addressed by Aerts, Gabora and Sozzo (AGS) is one that has proved highly challenging for the psychology of concepts, and in particular prototype theory. In my commentary, I will first try to clarify some of the theoretical issues that have proved problematic, and then suggest a parallel between the mathematical treatment of the problem offered by AGS and the attribute inheritance model that tries to explain some of these phenomena at a different level of analysis.

The first important point is that the notions of Typicality and Graded Membership should not be treated as a single construct or variable, as AGS have done. As Osherson and Smith (1981, 1995) pointed out, a robin and a penguin clearly have very different typicality as birds, as repeatedly demonstrated in direct typicality ratings, categorization times and so forth, yet as category members they both fulfil the criteria of membership completely – they are both fully paid-up members of the bird category. Not only are penguins clearly birds biologically, but a large majority of participants recognize this fact. So any model, such as one based on fuzzy logic, that proposes that there is a *degree of truth* to the statement "X is a bird" would have to give equal values of 1 to both robins and penguins. Clearly such a model will not be able to account for differences in typicality, only differences in graded membership.

Hampton (2007) explains the difficulty here, suggesting that both measures relate directly to the underlying dimension of similarity to prototype, but with different functions. While typicality declines monotonically with increasing distance or dissimilarity from the prototype, it is only when the similarity descends to a level near to the border of the category that gradedness of membership starts to appear. In a similar way, graded membership reaches zero (clear non-member) at a point where some similarity to the prototype still remains. Bats are similar to birds, but not sufficiently similar to have graded membership in the category greater than zero.

For these reasons, Hampton (1997) analysed the conjunction data twice, once looking at mean typicality ratings, and then again looking at true/false categorization probabilities. The AGS proposal makes no differentiation of these two variables, and indeed sometimes appears to take the combined typicality/membership ratings used in Hampton (1988a, 1988b) as if they were readings from some physical measuring device in physics. Before the application of complex quantitative models to these data, some consideration is necessary of (a) the statistical reliability of the reported values, and (b) the scaling properties of the dependent variables. To take the example of Overextension in conjunctions, first it is necessary to decide whether one is talking about typicality (as in the original guppy effect, and as modelled by Smith et al., 1988), or about categorization, as demonstrated in Hampton (1988b) and elsewhere. In either case the possibility of measurement error giving rise to observed violations of the constraints on conjunctive membership needs to be ruled out (see for example Huttenlocher & Hedges, 1994), and it would be sensible to collect data for a larger set of items using participant sample sizes sufficient to provide accurate estimates of categorization probabilities for each item. (For example the data from Hampton, 1988b, modelled by AGS had just 10 participants per item mean).

Having made this proviso, there is much in common between AGS and the model of conceptual combination that I have proposed in Hampton (1987, 2007). Take first their characterization of a concept as “an entity in a state changing under influence of a context”. AGS propose adopting this idea of a concept as an abstraction away from simple extensional accounts of conceptual categories, and it is surely the right move to make. The difficulties that both fuzzy logic and classical probability theory have with accounting for psychological conceptual judgments can be directly attributed to the basis of these theories in extensions (Cohen & Murphy, 1984). To make sense of conceptual intuitions, concepts have instead to be understood as intensions, that is to say as sets of generic properties characterizing the kind in question. Barsalou and Medin (1986) suggested that concept representations may in fact be constructed “on the fly” within a particular functional context. In keeping with some theories of pragmatics, it can be claimed that there is always some context within which a concept becomes instantiated on any particular occasion. Having a heavy degree of context dependence may also help clarify the puzzling polysemy that can be found in many concept terms (Nunberg, 1979). A concept such as NEWSPAPER can be instantiated, depending on context, as a physical object, a source of information, a journalist, a business, or even an office building.

The proposal that concepts are constructed afresh each time clearly fits well with the AGS notion of concepts only being instantiated within contexts and remaining in a state of abstraction or superposition until called upon to represent a particular situated thought. The suggestion also fits well with the common impression reported by participants in these experiments that they have never before considered whether (say) rhubarb is a fruit, or indeed what their own definition of a fruit might entail. The knowledge is held in an implicit form of memory that only becomes available to introspection within the context of a given question.

Having established the theoretical basis, AGS then use their model to account for the “non-logical” effects seen in prototype combinations. Overextension in conjunctions and disjunctions are modelled using the advanced mathematics of quantum probability. However it is perhaps unfair of them to claim as follows:

> *“Much effort has been devoted to these matters, but very few substantial results have been obtained. Actually, none of the traditional concept theories provides a satisfactory model for the dynamics of concepts and the way they combine” (p.2)*

In particular, the Composite Prototype Model (Hampton, 1987, 1988b) has had considerable success in accounting for the same phenomena, although it does so in a more qualitative fashion. Given the lack of precision in the measurement methods used to date, this avoidance of precise quantification seems warranted.

The Composite Prototype model proposes that when two concepts are placed in conjunction, their intensions (rather than their extensions) are combined. The intersection of an extension corresponds logically to the union of the intension. When two well-defined categories are conjoined, such as bachelor and Member of Parliament, then their intensions (unmarried, adult male and holder of the elected office of MP) are aggregated so that someone in the conjunction has to have all of the necessary properties of each of the conjuncts. Thus for well-defined categories the union of intensions simply leads to the same result as the intersection of extensions. All is well.

However as we know, prototype concepts contain properties in their intensions which are *generic* rather than necessary or defining. That is, most birds fly, most fruits have seeds or most fish breathe only water. Since it is possible to remain in the category while missing one or more of the category relevant properties, it is also possible that the conjunction of two prototype concepts may not inherit all of the generic properties of its conjunct parents. Default inheritance can be over-ridden when interaction effects are produced from the potential conflict between the two sets of properties. Pets are warm and affectionate, but fish are not. Fish are eaten grilled or baked, but pets are not. Consequently the conjunctive concept pet fish has to select one or other of the alternative properties, it cannot have them all. Pet fish are not warm and affectionate (this capacity is not possible for fish, and as Hampton (1987) showed, any property that is impossible for a conjunct is also impossible for the conjunction). Neither are pet fish eaten with tartare sauce. This is not impossible for pets, but it can easily be seen that it is incompatible with a host of other pet features, such as being cherished by their owners. An exemplar such as a guppy or goldfish will therefore be able to provide a better match to the conjunctive concept (they are neither affectionate nor eaten), than to either of the original concepts. Hence they will show the guppy effect in typicality judgments (greater similarity to the conjunctive prototype than to either conjunct). Storms et al. (2005) conducted a study with a large number of conjunctive categories and proved the existence of a significant number of items that overextend in terms of typicality (although ironically, guppy was not a case in point). As demonstrated by the Hampton (1988b, 1997) studies, this greater similarity can also lead to greater categorization probability. It is the overextension of conjunctions in terms of categorization probability that provides the real challenge to classical extensional treatments of concepts, and hence the strongest evidence for similarity-based prototype concepts.

The treatment of disjunctions is also covered in AGS. The composite prototype model has not been as well developed for disjunction as it has for conjunction. If one follows the logic of intensions and extensions, and their complementary relations, then just as you form the intension of a conjunction by taking the union of the two intensions, so one could propose forming the intension of a disjunction through the intersection of the two intensions. In a simple world of blocks, the disjunction of large red and small red blocks would be just the red blocks. However this simple rule only applies in highly restricted cases (for example where all blocks are either large or small). Hence the data for disjunctions reveal much more variety in the patterns of over- and under-extension seen. When two concepts appear to exhaust a category (e.g. fruits and vegetables together covering fresh produce), then the disjunction may become overextended to include other fresh produce that misses being either a fruit or a vegetable (like mushrooms, grains and nuts). On the other hand each concept may trigger a situational context which may influence the interpretation of the other, and lead to underextensions. Ashtrays and waste baskets were more likely to be categorized as Household Furnishings than in the disjunction Either Household Furnishing or Furniture. It is possible that this underextension occurs where there is overlap (as opposed to contrast) between the two categories, but this remains speculative.

In sum, the QP model provides a different level of analysis of the problems of conceptual combination. I see no difficulty in integrating the mathematical treatment with the intensional treatment afforded by the Composite Prototype Model. For progress to be made, it should be a common goal to make closer links between the parameters within the mathematical model and measurable aspects of the concept intensions.

References

Aerts, D., Gabora, L., & Sozzo, S. (2013) Concepts and Their Dynamics: A Quantum-Theoretic Modeling of Human Thought. *TopiCS.*

Barsalou, L. W. & Medin, D. L. (1986). Concepts - static definitions or context-dependent representations? *Cahiers de Psychologie Cognitive-Current Psychology of Cognition, 6,* 187-202.

Cohen, B. & Murphy, G. L. (1984). Models of concepts. *Cognitive Science, 8,* 27-58.

Hampton, J. A. (1987). Inheritance of attributes in natural concept conjunctions. *Memory & Cognition, 15,* 55-71.

Hampton, J. A. (1988a). Disjunction of Natural Concepts. *Memory & Cognition, 16,* 579-591.

Hampton, J. A. (1988b). Overextension of conjunctive concepts: Evidence for a Unitary Model of Concept Typicality and Class Inclusion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 12-32.

Hampton, J. A. (1997). Conceptual combination: conjunction and negation of natural concepts. *Memory & Cognition, 25,* 888-909.

Hampton, J. A. (2007). Typicality, Graded Membership and Vagueness. *Cognitive Science, 31,* 355-383.

Huttenlocher, J. & Hedges, L. V. (1994). Combining graded categories: membership and typicality. *Psychological Review, 101,* 157-165.

Nunberg, G. (1979). The non-uniqueness of semantic solutions. Polysemy. *Linguistics & Philosophy, 3,* 143-184.

Osherson, D. N. & Smith, E. E. (1981). On the adequacy of prototype theory as a theory of concepts. *Cognition, 11,* 35-58.

Osherson, D. N. & Smith, E. E. (1997). On typicality and vagueness. *Cognition, 64,* 189-206.

Smith, E. E., Osherson, D. N., Rips, L. J., & Keane, M. (1988). Combining Prototypes: A Selective Modification Model. *Cognitive Science, 12,* 485-527.

Storms, G., De Boeck, P., van Mechelen, I., & Ruts, W. (2005). Not guppies, nor goldfish, but tumble dryers, Noriega, Jesse Jackson, panties, car crashes, bird books, and Stevie Wonder. *Memory & Cognition, 26,* 143-145.