Deference and Essentialism in the Categorization of Chemical Kinds

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Abstract

Psychological essentialism has been subject to much debate. Yet a key implication – that people should defer to experts in categorizing natural kinds – has not been widely examined. Three experiments examine deference in the categorization of chemical kinds. The first establishes borderline cases used in the second and third. These latter show limited deference to experts, and some deference to non-experts. These data are consistent with a perspectival framework for concepts in which categorization is sometimes based on micro-structural properties and sometimes on appearance and function.

Introduction

According to psychological essentialism (Medin & Ortony, 1989) people believe that kinds have essences – things that make an object what it is – and act accordingly. For example, people might believe that horses have an essence – that all horses necessarily have the essence, and that something cannot be a horse without it. Behaviour is predicated on a belief in the possession of the essence: people should behave differently with an animal they come to believe lacks the horse-essence, and should withhold the word 'horse' as its category label. This psychological essentialism differs from metaphysical essentialism (cf. Kripke, 1980; Putnam, 1975), which is the view that natural kinds actually do possess essences. According to psychological essentialism people believe that kinds have an essence even if this belief turns out to be false (cf. Mayr, 1988).

Much evidence has been cited as supporting psychological essentialism (cf. Gelman, Coley & Gottfried, 1994). For example, Keil (1989) and Rips (1989) showed that similarity based on superficial appearances could dissociate from categorization. People may go beyond appearances to seek deeper, causal principles as to why instances belong to categories. Such principles appear important even for very young children (Gelman, 2000; Gelman & Medin, 1993). In an influential series of studies, Gelman & Wellman (1991) showed that 4 and 5 year olds categorized items according to the nature of their insides, and their innate potential rather than their outward appearance or environment.

However, other empirical studies have suggested the relative unimportance of essences. Smith & Sloman (1994) showed that Rips' demonstrated dissociation between categorization and similarity could only be obtained under certain task conditions. Malt (1994), showed that the categorization of instances of water is not fully explained by the proportion of H_2O people believe the instances contain. For example, tears were less likely to be judged a type of 'water' than pond water, yet tears were thought to contain more H_2O. Malt argued that categorizing liquids as 'water' depends not just on their microstructure, but also on other factors such as function and source. Braisby, Franks & Hampton (1996) presented their participants with some of the thought experiments used by Kripke and Putnam to articulate, and argue for, metaphysical essentialism. They found that their participants did not agree with the intuitions of Kripke and Putnam and argued that their participants were not truly essentialist, but sometimes gave more weight to micro-structural properties and sometimes more to appearance and function (though see Diesendruck & Gelman, 1999).

There are further difficulties with the evidence claimed to support essentialism. First, as conceded by Gelman, Coley & Gottfried (1994), since participants are unlikely to articulate essentialist beliefs explicitly, much of the evidence for essentialism is indirect. That is, there is an inferential step between the information manipulated in studies, and an essentialist conclusion. For example, Gelman & Wellman (experiment 2) manipulated insides and outsides, and argued that the dependence of categorization on insides supports essentialism. Yet the argument requires a further premise – that children regard insides as essential. Without this, the essentialist conclusion is uncertain. As Fodor (1998) puts it "What's further required … is the idea that what's 'inside' … is causally responsible for how things that belong to the kind appear…" (p. 154–155). Similarly Strevens (2001) suggested that the evidence cited in favour of essentialism can be explained by the simpler belief that causal laws relate category membership to appearances, and do not warrant invoking the notion of essence (see the discussion between Ahn, Kalish, Gelman, Medin, Luhmann, Atran, Coley & Shafto, 2001, and Strevens, 2001).

The studies reported here take a different tack. They focus on a key implication of essentialism that has remained relatively unexplored. Putnam (1975) developed a corollary of essentialism that he labeled the Division of Linguistic Labour (DLL). Though the arguments were constructed around word meaning, they have been widely taken to apply to concepts (e.g., Fodor, 1998). According to DLL, people should defer to experts, i.e., those with more knowledge of a category's likely essential properties. For instance, if a metallurgist categorizes a watch as "not gold," other things being equal, essentialism requires lay people's categorizations to conform.

In spite of theoretical studies of deference (e.g., Fodor, 1998; Segal, 2000; Woodfield, 2000), there have been few empirical examinations either of the extent of deference, or even whether it occurs. Malt (1990) presented her participants with objects that were described as appearing 'halfway' between two categories (e.g., a tree halfway between an oak and a maple). She asked them to choose one of three response options to signal how they would resolve the object's category membership: 'ask an expert', 'call it whichever you want' or judge that, with more time, they could 'tell which it is'. For natural kinds, 75% of participants chose 'ask an expert', whereas for artifacts (e.g., 'boat-ship'), 63% chose 'call it whichever you want'. However, this evidence is only suggestive of the importance of expert opinion in categorization: participants could choose not to defer to an expert whose opinion they sought. Braisby (2001) examined deference more directly by looking at the categorization of borderline biological kinds. Around half of his participants switched their categorization judgments to agree with those of experts. However, one quarter did the same with non-expert judgments. Braisby argued that the data overall did not support psychological essentialism since participants did not consistently defer and based their judgments on non-essential properties such as appearance and function as well as 'essential' properties.

This paper focuses on deference in categorizing chemical kinds. Much of the original argumentation for essentialism is based on natural kinds, yet empirical studies have almost exclusively focused on biological kinds. Yet there are reasons to think that the categorization of biological and chemical kinds may differ. First, it has been argued that metaphysical essentialism is not true for biological species (cf. Dupre, 1999; Mayr, 1988;), whereas similar arguments do not appear, for example, for the periodic table. Second, there is increasing evidence of the universal and domain-specific nature of biological thought (cf. Hirschfeld & Gelman, 1994). If biological thought is domain-specific, then it follows that the principles governing 'chemical' thought may differ. Finally, there is much evidence that biological thought has a privileged folk status (e.g., Atran, 1998), though there have been no similar arguments for chemical kinds.

The first experiment establishes borderline cases of chemical kinds. The second examines whether people defer to experts in categorizing these cases. The third considers whether people also 'defer' to non-experts.

Experiment 1

Design

Participants were randomly assigned to one of two conditions: Appearance Unaltered and Appearance Altered.

Method

Participants 60 undergraduate psychology students attending an Open University residential school volunteered to participate.

Materials Four chemical kinds were chosen, that were also familiar household items: vitamin C, salt, water and soap. Scenarios were constructed to describe transformations of the kinds that were intended to produce borderlines. An example of an Appearance Unaltered scenario follows. "You have just bought a bottle of water from a reputable retailer. On examining its packaging closely you find that it has been produced by a new process that involves chemically transforming water. The transformation is such that the manufacturers have had to give the liquid a new chemical formula. However, the liquid looks, feels, smells and tastes just like water." For Appearance Altered scenarios the final sentence was altered – for example, to "Although the liquid looks, feels and tastes just like water, you notice that it smells unusual." Scenarios were constructed for each kind following the same template, the only differences being due to the name of the kind, and this final sentence.

Procedure Participants were presented with 4 scenarios, as above. Half of the participants in each condition were presented with these scenarios in a random order; the rest saw them in reverse order. All participants were given a practice example. After each scenario, they were presented with a categorization question (e.g., "is the liquid you have bought water?") and asked to give a (forced-choice) Yes/No judgment. Participants were instructed to answer solely on the basis of the current scenario, and ignore preceding scenarios and answers. After completing the task, participants were asked to rate its difficulty on a 7-point scale (1 = very easy, 7 = very difficult).

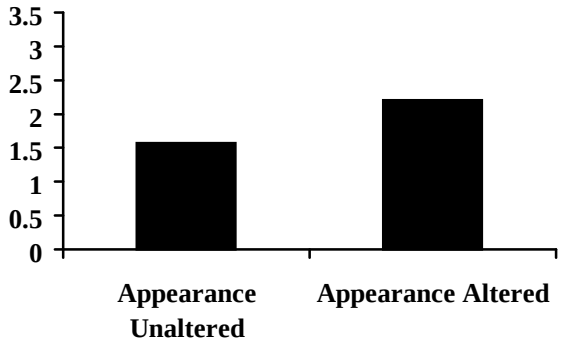

Figure 1. Mean no. of Yes responses in experiment 1 by type of transformation (maximum = 4).

Results

The mean difficulty rating for the task was 3.8; this did not differ for the two transformations. Figure 1 shows the mean number of Yes responses (maximum = 4). Both transformations resulted in the chemical kinds being treated as borderline cases (i.e., the proportion of positive categorizations was roughly 2, or 50%). A one-way ANOVA showed that the difference between the two kinds of transformation was not significant.

Discussion of Experiment 1

The changes in chemical structure produced borderline items of the chemical kinds: for both transformations the proportion of positive categorizations hovered around 50%. These scenarios are therefore highly suitable for investigating deference, since the influence of expert opinion is likely to be greatest for uncertain categorizations. Moreover, the difficulty rating suggests participants easily understood the task and scenarios.

Experiment 2

This experiment considers how categorization depends on information concerning experts' categorizations.

Design

Participants were randomly assigned to one of two conditions: Appearance Unaltered and Appearance Altered. All participants gave categorization judgments for both Positive and Negative expert categorizations.

Method

Participants 60 undergraduate psychology students attending a residential school volunteered to participate. None participated in experiment 1.

Materials The same chemical kinds and scenarios as in experiment 1 were used. Scenarios were adapted to incorporate information concerning the categorization judgments of scientific experts. To determine which occupational group would be considered most expert, 30 additional participants (that did not participate in the other experiments reported here) provided two different ratings. First, they indicated how knowledgeable they thought different occupational groups would be of each of the four kind's chemical properties. Second, for each kind, they indicated the extent to which they would trust the categorization judgments of the different occupational groups. All ratings were given on a 7-point scale (knowledge ratings: 1 = very little or no knowledge, 7 = extremely knowledgeable; trust ratings: 1 = 'do not trust members of the profession at all,' 7 = 'trust members of the profession absolutely'). The group with the highest combined knowledge and trust ratings was 'Chemists' (5.7).

Scenarios were adapted to include an additional sentence prior to the final one. For example, for a positive Appearance Unaltered scenario the following sentence was added: "You also discover that according to most chemists the liquid you have bought is, in fact, water." Negative scenarios were obtained by replacing "is" with "is not". Appearance Altered scenarios differed in the final sentence, as for experiment 1.

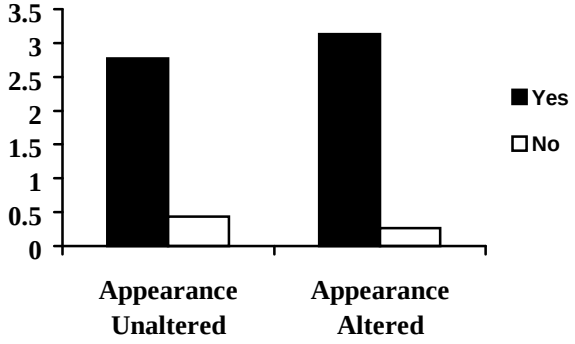

Figure 2. Mean no. of Yes responses in experiment 2 by transformation and expert judgment (max = 4).

Procedure A similar procedure to experiment 1 was used. Participants were presented with 8 scenarios: each of the 4 chemical kinds was presented twice, once with a positive and once with a negative expert judgment. As in experiment 1, participants were instructed to respond solely on the basis of the current scenario, and ignore any previous scenarios and responses. In each Transformation condition, half of the participants were presented with scenarios in a random order; the remainder saw these in the reverse order.

Results

The mean difficulty rating was 3.7; this did not differ for the two kinds of transformation. The mean number of Yes responses according to transformation and expert categorization is given in figure 2. When the chemists were described as giving positive categorization judgments, participants tended to give positive judgments too. Similarly, when the experts were described as giving negative categorization judgments, so did participants.

A two-way ANOVA, with Transformation (Appearance Unaltered, Appearance Altered) as a between-subjects factor, and Expert Judgment (Yes, No) as a within-subjects factor revealed no difference between the two transformation conditions. There was a significant effect of Expert Judgment however (Yes condition: mean = 3.0; No condition: mean = 0.4; $F = 121.18$, $df = 1,58$, $p < 0.001$). There was no interaction between Expert Judgment and Transformation. These results were confirmed by an item analysis (Expert Judgment: $F = 191.12$, $df = 1,6$, $p < 0.001$)

Although figure 2 suggests a dramatic switch in people's categorization depending on expert judgment,

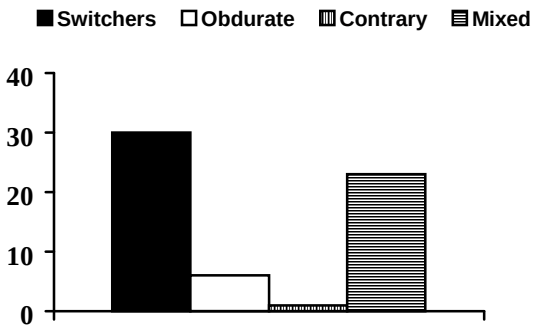

Figure 3. Numbers of participants adopting the four response patterns in experiment 2 (N = 60).

these are group data, and so do not directly reveal the extent to which individuals switch their categorizations. Consequently, individuals who adopted a consistent response pattern across all four kinds were classified into one of three types: Switchers, who responded Yes when the chemists' judgment was Yes and No when the chemists' judgment was No; Obdurate, who maintained their categorizations (either Yes or No) regardless of the chemists' judgments; and Contrary, who gave opposing judgments to those of the chemists. Finally, those who did not consistently adopt one of these three patterns were labeled Mixed. Participants' ratings of task difficulty did not differ across the four types; the numbers of participants falling into these types did not differ by transformation (chi-square(3) = 1.04, p = 0.79). As shown in figure 3, 50% of participants were Switchers. Of the remainder, 1 was Contrary; 6 were Obdurate; and 23 (more than one-third) did not adopt a consistent pattern for all 8 scenarios. Of these latter, 22 showed a pattern of being Obdurate for roughly 50% of scenarios and Switching for the rest. However, there was no consistency over which chemical kinds produced obduracy or switching across individuals.

Discussion of Experiment 2

Overall, information concerning experts' (chemists') categorization judgments appears to exert a dramatic influence on participants' categorizations. However, while these data appear consistent with a division of linguistic labour, and hence with essentialism, the data do not offer strong support.

First, the extent of Switching in the group data is represented by the difference between the Yes and No conditions, i.e., 3 out of 4 minus 0.4 out of 4 (= 2.6 or 55%). That is, only a small majority of responses overall show Switching. Second, the group data mask how expert categorizations influence individuals. Individuals are influenced in different ways, but only 50% consistently switched their categorizations to agree with the experts. Moreover, these data need careful interpretation since they only show the effect of expert judgment on categorization. As suggested earlier, deference is predicated on perceived knowledge of a category's essential properties. It is therefore necessary to consider whether deference might emerge even in the absence of expertise. If it does, then the case for essentialism is correspondingly weakened.

Experiment 3

This experiment considers how categorization depends on information concerning non-experts' categorizations.

Design

Participants were randomly assigned to one of two conditions: Appearance Unaltered and Appearance Altered. Participants gave categorization judgments for both Positive and Negative non-expert categorizations.

Method

Participants 60 undergraduate psychology students attending a residential school volunteered to participate. None participated in experiments 1 or 2.

Materials The same chemical kinds in experiments 1 and 2 were used. Scenarios were adapted from those in experiment 2 to include the categorization judgments of non-experts. Using the same ratings of occupational groups described earlier, 'Shoppers' was chosen as the non-expert group because they lack (chemical) expertise (mean combined knowledge and trust rating = 2.3) yet have considerable familiarity with the chemical kinds. Scenarios were modified so that the word 'shopper(s)' replaced the word 'chemist(s)'. All other materials were identical to those of experiment 2.

Procedure This was identical to that of experiment 2.

Results

The mean difficulty rating was 3.5; this did not differ for the two kinds of transformation. The mean number of Yes responses according to transformation and non-expert categorization is shown in figure 4. When the shoppers were described as giving positive categorization judgments, participants tended to give positive judgments too. When the non-experts gave negative categorization judgments, so did participants.

A two-way ANOVA, with Transformation (Appearance Unaltered, Appearance Altered) as a between-subjects factor, and Non-expert Judgment (Yes, No) as a within-subjects factor, showed there was no effect of Transformation. There was a significant effect of Non-expert Judgment however (Yes condition: mean = 1.9; No condition: mean = 1.1; F = 10.32, df = 1,58, $p < 0.01$). There was no interaction between Non-expert Judgment and Transformation. These results

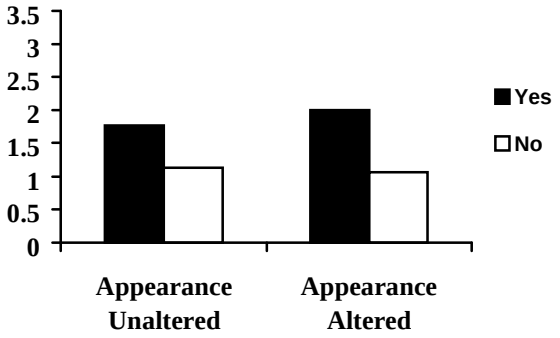

Figure 4. Mean no. of Yes responses in experiment 3 by type of transformation and non-expert categorization (maximum = 4).

were confirmed by item analysis also (Non-expert Judgment: $F = 4.51$, $df = 1,6$, $p = 0.08$).

As before, these data were analysed according to the four individual response types: Switcher, Obdurate, Contrary and Mixed. Participants' ratings of task difficulty did not differ across the four types; the numbers of participants falling into the four types did not differ by transformation (chi-square(3) = 3.90, $p = 0.27$). Numbers of participants falling into these types of response pattern are shown in figure 5.

Approximately 50% of participants adopted a mixed pattern of responses. Of these, most participants showed a pattern of mostly obduracy, with some switching and fewer contrary categorizations. Of the remainder, 2 participants were Contrary; 15 were Obdurate; and 9 were Switchers.

Discussion of Experiments 2 and 3

Overall participants tended not to switch their categorizations when given information about non-expert judgment. Nevertheless, the extent of Switching in the group data amounts to 0.8 out of 4 (20%); 9 individuals (15%) consistently Switched. Thus there is evidence of some limited, but surprising deference.

The number of Yes responses for experiments 2 and 3 were analysed in a three-way ANOVA with Transformation (Appearance Unaltered, Appearance Altered) and Expertise (Chemists, Shoppers) as between-subject factors, and Judgment (Yes, No) as a within-subjects factor. This revealed an effect of Judgment (Yes condition: mean = 2.42, No condition = 0.73; $F = 99.35$, $df = 1,116$, $p < 0.001$), and an interaction between Judgment and Expertise ($F = 28.64$, $df = 1,116$, $p < 0.001$), showing that the patterns in figures 2 and 4 differ. Item analysis confirmed the main effect of Judgment ($F = 37.61$, $df = 1,6$, $p < 0.01$) and the interaction with Expertise ($F = 85.07$, $df = 1,6$, $p < 0.001$). The numbers of individuals adopting the four different response patterns also differed by Expertise (chi-square(3) = 17.62, $p < 0.01$).

General Discussion

Overall these experiments reveal a limited difference in the way that information about expert and non-expert categorization judgments influences people's categorizations and hence only a limited amount of deference in categorizing chemical kinds. The group data suggest that only 45% (i.e., 65% in experiment 2 minus 20% in experiment 3) of categorizations switched because of the expertise (and presumed knowledge of essential properties) of chemists; the individual data suggest that only 35% of Switchers do so because of the chemists' expertise.

Why do only a minority of individuals consistently defer? One possibility is that psychological essentialism should not be interpreted so strongly. There are some hints of this in writings supporting essentialism, that variously refer to an essentialist 'bias' or 'heuristic'. This move would maintain consistency between essentialism and these otherwise recalcitrant data, but at a price. If people are credited as essentialist even when their categorizations are only sometimes based on essential properties, then essentialism loses explanatory value. In these experiments, for example, an appeal to essentialism would help explain only the minority of categorizations that involve switching; the remaining categorizations would still be in need of explanation.

Another possibility is that the connection between essentialism and deference is weaker than assumed. The prediction that people should defer to experts is predicated on a conjunction of beliefs – people believe that essential properties determine category membership, that experts are knowledgeable about the relevant essential properties and that, generally speaking, expert judgment is reliable – and the presumption of rationality (that people should rationally follow the implications of their multiple beliefs). Anyone of these claims could in principle be in error. If so, these data could point to an elaboration of psychological essentialism, one that clarifies its commitments and implications. One possibility is, for

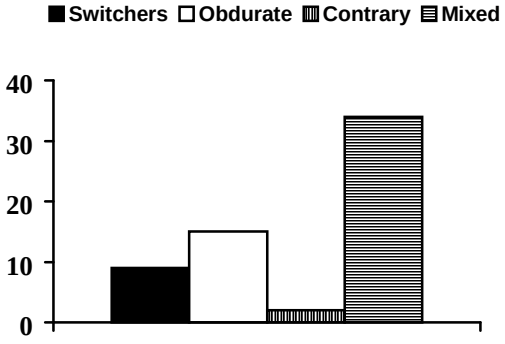

Figure 5. Numbers of participants adopting the four response patterns in experiment 3 (N = 60).

example, that essentialism makes different claims for chemical as opposed to biological kinds.

Alternatively, consistent with the suggestions of Braisby, Franks & Hampton (1996), these data may point to the need for an account that treats categorization as flexible. According to a perspectival view, concepts have a content that shifts systematically according to perspective and context (Braisby, 1998). Concepts may then reflect micro-structural properties from some perspectives, but appearance and/or functional properties from others. These findings would then suggest that, in categorizing chemical kinds, people experience a conflict between deferring to experts based on their knowledge of micro-structural properties and being influenced by appearance and functional properties. If this is right, then a comprehensive account of concepts will need to provide a framework for different kinds of categorization (cf. Smith & Sloman, 1994) – that is, different ways (both essentialist and non-essentialist) in which people can think about chemical kinds.

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References

Ahn, W., Kalish, C., Gelman, S. A., Medin, D. L., Luhmann, C., Atran, S., Coley, J. D. & Shafto, P. (2001). Why essences are essential in the psychology of concepts. *Cognition, 82*, 59–69.

Atran, S. (1998). Folk biology and the anthropology of science: cognitive universals and cultural particulars. *Behavioral and Brain Sciences, 21*, 547–609.

Braisby, N. (1998). Compositionality and the modelling of complex concepts. *Minds and Machines, 8(4)*, 479-508.

Braisby, N. R. (2001). Deference in categorisation: Evidence for essentialism. In J. D. Moore & K. Stenning (Eds.), *Proceedings of the Twenty-Third Annual Conference of the Cognitive Science Society*. Mahwah, NJ.: Lawrence Erlbaum.

Braisby, N., Franks, B., & Hampton, J. (1996). *Essentialism, word use, and concepts. Cognition, 59*, 247-274.

Diesendruck G. & Gelman S. A.(1999). Domain differences in absolute judgments of category membership: Evidence for an essentialist account of categorization. *Psychonomic Bulletin & Review, 6(2)*, 338-346.

Dupre, J. (1999). Are whales fish. In D. L. Medin & S. Atran (Eds.), *Folkbiology*. Cambridge, MA.: MIT Press.

Fodor, J. (1998). *Concepts: Where cognitive science went wrong*. Oxford: Oxford University Press.

Gelman, S. A. (2000). The role of essentialism in children' s concepts*Advances in Child Development and Behavior, 27*, 55-98.

Gelman, S. A., Coley, J. D. & Gottfried, G. M. (1994). Essentialist beliefs in children: the acquisition of concepts and theories. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the Mind: domain specificity in cognition and culture*. Cambridge, CUP.

Gelman, S. A. & Medin, D. L. (1993). What's so essential about essentialism? A different perspective on the interaction of perception, language, and conceptual knowledge. *Cognitive Development, 8*, 157-167.

Gelman, S. A., & Wellman, H. M. (1991). Insides and essences: Early understandings of the nonobvious. *Cognition, 38*, 213-244.

Hirschfeld, L. A. & Gelman, S. A. (Eds.) (1994). *Mapping the Mind: domain specificity in cognition and culture*. Cambridge, CUP.

Keil, F. C. (1989). *Concepts, kinds and cognitive development*. Cambridge: MIT Press.

Kripke, S. (1980). *Naming and necessity*. Cambridge: Harvard University Press.

Malt, B. C. (1990). Features and beliefs in the mental representation of categories. *Journal of Memory and Language, 29*, 289–315.

Malt, B. C. (1994). Water is not H_2O. *Cognitive Psychology, 27*, 41-70.

Mayr, E. (1988). *Toward a new philosophy of biology*. Cambridge, MA.: Belknap Press.

Medin, D. L. & Ortony, A. (1989). Psychological essentialism. In S. Vosniadou and A. Ortony (Eds.), *Similarity and analogical reasoning*. New York: Cambridge University Press.

Putnam, H. (1975). The meaning of ' meaning.' In H. Putnam, *Mind, language, and reality: Philosophical papers, vol. 2*. Cambridge: Cambridge University Press.

Rips, L. J. (1989). Similarity, typicality, and categorization. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning*. New York: Cambridge University Press.

Rosch, E. H. (1975).Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*, 192-233.

Rosch, E. H. & Mervis, C. B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7*, 573-605.

Segal, G. (2000). *A slim book about narrow content*. Cambridge, MA.: MIT Press.

Strevens, M. (2000). The essentialist aspect of naïve theories. *Cognition, 74*, 149–175.

Strevens, M. (2001). Only causation matters: reply to Ahn et al. *Cognition, 82*, 71–76.

Smith, E. E. & Sloman, S. A. (1994). Similarity- versus rule-based categorisation. *Memory & Cognition, 22(4)*, 377–386.

Woodfield, A. (2000). Reference and deference. *Mind and Language, 15(4)*, 433–451.