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An Empirical Examination of Intuitive Expectation Sets

M. Afzal Upal

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Abstract

This report presents the results of a series of studies carried out to understand people's mental representation of common concepts. The results support some aspects of previous research and question some previous assumptions. This work will not only allow cultural scientists to better understand the spread of non-natural and religious concepts but also allow the Canadian Armed Forces's (CAF) influence activities practitioners to design messages that are more memorable for their target audiences.

Résumé

Le présent rapport fait état des résultats d'une série d'études qui visent à comprendre la représentation mentale de concepts courants. Les résultats viennent corroborer certains aspects de travaux de recherche antérieurs et remettent en question quelques-unes des hypothèses antérieures. Ces travaux permettront non seulement aux scientifiques des cultures de mieux comprendre la diffusion des concepts non naturels et religieux, mais également aux professionnels du marketing et aux praticiens des activités d'influence des FAC de concevoir des messages qui seront plus mémorables pour les publics cibles.

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Executive summary

An Empirical Examination of Intuitive Expectation Sets

M. Afzal Upal; DRDC Toronto TM 2013-153; Defence R&D Canada, Toronto Research Centre; November 2013.

Introduction and background: The Canadian Armed Forces (CAF) have the capability to model the physical effect of kinetic operations in exquisite detail. Models exist that can describe the physical impact of a bomb blast: what the crater will look like, how many floors a bomb will traverse, and what type of external damage should be expected for any specific weapon. In contrast, the CAF has no modeling or analytic capability to understand how its actions will impact the psychological meaning space of individuals. The psychological meaning space of an individual is defined as an individual's semantic memory which allows her/him to make sense of a concept. The capability to understand how its actions are seen by a target population is becoming increasingly important for planning all CAF missions and is crucial to fighting and winning asymmetric wars. In this research, we begin to develop formal methods to map the psychological meaning space of individuals, identifying how people organize their knowledge of various common categories.

Results: The results support the idea that people have intuitive/folk notions about various object categories, but they suggest revisions to some of the particular intuitive expectations.

Significance: This work will not only allow cultural scientists to better understand the spread of non-natural and religious concepts but also allow the CAF's influence activities practitioners to design messages that are more memorable for their target audiences.

Future plans: The CAF's influence activities practitioners employ a number of common themes/concepts in their messages in the field including notions of war and peace. We plan to carry out a study of the concepts commonly used by these practitioners in their messages. We will then study how people from different cultures represent these concepts to see whether there are widespread cultural differences. The results of this work will allow the CAF's influence activities practitioners to make informed decisions about how their concepts are likely to be understood by their target audience members.

Sommaire

An Empirical Examination of Intuitive Expectation Sets

M. Afzal Upal; DRDC Toronto TM 2013-153 ; R & D pour la défense Canada – Toronto; novembre 2013.

Introduction et contexte : Les Forces armées canadiennes (FAC) ont la capacité de modéliser les effets physiques des opérations cinétiques dans les moindres détails. Il existe des modèles pouvant décrire les répercussions physiques d'une détonation : l'apparence prévue du cratère, le nombre d'étages qu'une bombe peut traverser et le type de dommages extérieurs attendus d'une arme précise. Par contre, les FAC ne disposent d'aucune capacité de modélisation ou d'analyse qui leur permettrait de comprendre dans quelle mesure leurs actions influent sur l'espace de signification psychologique des gens. L'espace de signification psychologique, c'est la mémoire sémantique d'une personne qui lui permet de donner du sens à un concept. Il devient de plus en plus important de comprendre dans quelle mesure les actions des FAC sont perçues par une population cible pour planifier toutes les missions des FAC, et cela est crucial pour mener et gagner des guerres asymétriques. Dans le cadre de cette recherche, nous commençons à élaborer des méthodes structurées pour « cartographier » l'espace de signification psychologique des gens, en déterminant la façon dont ils organisent leur connaissance de diverses catégories communes.

Résultats : Les résultats viennent corroborer certains aspects de travaux de recherche antérieurs tout en remettant en question d'autres hypothèses.

Importance : Ces travaux permettront non seulement aux scientifiques des cultures de mieux comprendre la diffusion des concepts non naturels et religieux, mais également aux professionnels du marketing et aux praticiens spécialistes des activités d'influence des FAC de concevoir des messages qui seront plus mémorables pour les publics cibles.

Projets futurs : Les praticiens des activités d'influence des FAC utilisent un certain nombre de thèmes/concepts communs dans leurs messages sur le terrain, notamment des notions de guerre et de paix. Nous nous proposons de mener une étude des concepts couramment utilisés par ces praticiens dans leurs messages. Nous examinerons ensuite comment ces concepts sont représentés par des gens de cultures différentes pour déterminer s'il existe des différences culturelles répandues. Les résultats de cette étude permettront aux praticiens des activités d'influence des FAC de prendre des décisions éclairées sur la façon dont leurs concepts pourraient être compris par les membres du public cible.

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Acknowledgements

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1 Introduction

To win the hearts and minds of a population, the Canadian Armed Forces (CAF) need to design effective information campaigns. In order to help the CAF in this endeavor, we need to better understand why some ideas flourish and become widely transmitted in a population while others quickly perish after their creation. Previous work by the Principal Investigator (PI) of this study (Upal, 2005; Upal, Gonce, Tweney, & Slone, 2007) and others (Barrett & Nyhof, 2001; Boyer & Ramble, 2001) has shown that minimally counterintuitive (MCI) concepts (e.g., a tree that barks) are better remembered and recalled than maximally counterintuitive concepts (e.g., a tree that smiles and barks) as well as intuitive concepts (e.g., a tree that grows). The explanations for this minimal counterintuitiveness effect, however, have been debated by cognitive scientists. The *content-based* view advocated in Boyer (1994), Boyer and Ramble (2001), and Barrett and Nyhof (2001) and most clearly articulated in Barrett (2008) emphasizes the unique psychological aspects of minimally counterintuitive concepts. The *context-based* model presented in Upal (2005), Upal et al. (2007), Upal (2009), and Harmon-Vukic, Upal, and Sheehan (2012) views minimally counterintuitive concepts as ideas that violate people's expectations and emphasizes the role that context plays in making them surprising and memorable.

Boyer and Ramble (2001) and Barrett (2008) argue that MCI concepts are remembered better because they evoke mental modules that deal with input from two different domains. Boyer (1994) and Boyer and Ramble (2001) focus on the domains of reasoning about animals, artifacts, and persons and specify counterintuitiveness in terms of the transfer of properties from one domain to another or the breach/negation of expectations invoked by a domain. Barrett (2008) adds to these domains. His domains include "*Spatial Entities, Solid Objects, Living Things* that do not appear to be self propelled, *Animates*, and *Persons* [original emphasis]" (p. 317). Barrett also clearly articulates the expectations that people derive from each domain. His intuitive expectation sets are reproduced in Table 1. The list is meant to be exhaustive, although Barrett admits that it "may need to be expanded as more assumptions are discovered" (Barrett, 2008, p. 335).

Table 1: Barrett's intuitive expectation sets, taken from Barrett (2008).

Intuitive expectation set	Properties assumed
Spatiality	Specifiable location in space and time
Physicality	Cohesion (move as connected whole)
	Contact (physical contact required for launching or changing direction of movement)
	Continuity (movement is continuous in space)
	Solidity (cannot pass through or be passed through by other solid objects)
	Tangibility
	Visibility
Biology	Growth and development
	Like begets like
	Natural composition
	Nourishment needs and processes to satisfy these needs (if animate, active seeks to satisfy these needs)
	Parts serve the whole to sustain life
	Vulnerability to injury and death (if animate, seeks to avoid injury and death)
	Kind-specific essence
Animacy	Goals
	"Self-propelled" (including moving in space, changing appearance, emitting sounds, etc.)
Mentality	Reflective & representational mental states (e.g., beliefs, desires) and standard relationships among them and limitations of them (e.g., limited perceptual access)
	Self-awareness (including emotions and epistemic states)
	Understand language and communication
Universals	Consistency (assumptions apply continuously; past was like the present, future will be like present)
	Time (and hence causation is unidirectional)

According to the context-based view, which ideas are surprising to a person depend on the person's mental representation of relevant concepts that forms part of the context in which the idea is processed. This draws on decades of cognitive science research on concept learning (Anderson, 1990; Collins & Loftus, 1975; Myers, O'Brien, Balota, & Toyofuku, 1984) which suggests that people learn to organize their conceptual knowledge in a structured way. Mental representations of the objects and events that frequently co-occur in an agent's environment come to be strongly interconnected in that environment. If an object or event is seen in isolation, its links with its unseen neighboring concepts get weaker. Thus, over time, an agent's memory comes to reflect the perceived frequency of co-occurrence of different objects and events (Ellis, 2006). If, for example, an agent lives in a world where most birds have feathers, the two concepts become strongly interconnected. When a concept such as a bird is activated, the concept of feathers also becomes activated in the agent's mind. However, if the agent learns that the bird in question does not have any feathers, then his/her expectation is violated, and a learning opportunity presents itself. In order to benefit from this opportunity, however, the agent must be able to justify that the lack of feathers does not preclude the animal from being a bird. If this justification process results in a coherent concept, then that concept is remembered; if it does not, the concept is discarded. Minimally counterintuitive concepts are remembered better because people are able to create justifications for them, whereas maximally counterintuitive concepts are too unwieldy and incoherent to be justified.

To make precise predictions about memory for various types of concepts, we need to better understand how these concepts are represented in the minds of target audience members. Such work can help us answer questions about whether people's expectations are organized into intuitive sets and if so what these intuitive sets look like. Unfortunately, little work has been done

to empirically investigate these questions. The studies reported here were designed to fill this gap by eliciting the expectations that people have about various common categories.

2 Experiment 1

The first study used some of the statements from Table 1 to determine the degree to which people expect the category properties and features hypothesized by Barrett (2008). The following 13 statements were derived from Table 1.

1. All solid objects move as connected wholes.
2. Physical contact is required for launching or changing the direction of movement of all solid objects.
3. All living beings have nourishment needs and processes to satisfy these needs.
4. Bodies of all living beings are composed of natural substances.
5. All living beings grow and develop over time.
6. All living beings produce offspring that are similar to them.
7. All animals have goals, and they take actions to satisfy those goals.
8. All animals are self-propelled.
9. All mental beings can perceive the world through their sensors.
10. All mental beings have beliefs and desires.
11. All mental beings have self-awareness.
12. All mental beings have emotions.
13. All mental beings understand and speak languages to communicate with others.

To these we added another six statements from the category of superhero to study people's expectations about supernatural categories that are so prevalent in popular culture and religion.

14. Superheroes can fly through the air.
15. Superheroes can leap over skyscrapers.
16. Superheroes can see through walls.
17. Superheroes can hear whispers from miles away.
18. Superheroes can become invisible.
19. Superheroes can walk through walls.

2.1 Participants

One hundred and fifty adult male and female participants were recruited using Amazon's Mechanical Turk, for a small reward for answering the survey questions.

2.2 Materials & Procedures

The materials consisted of a webpage containing the 19 statements shown above. Participants were asked to indicate the degree to which they agreed or disagreed with each statement by selecting a number from –3 to +3 on a Likert scale labeled "strongly disagree" to "strongly agree."

2.3 Results and Discussion

The total percentage of participants who disagreed (those who selected –3 to –1) was subtracted from the total percentage of the participants who agreed (those who selected +1 to +3) to compute the relative agreement with a statement. (The number of participants who selected 0 was left out of the calculation.) The results are shown below in Table 2.

Table 2: Difference between percentage of people who agree and disagree with each statement.

Statement	Relative Agreement
All solid objects move as connected wholes.	29
Physical contact is required for launching or changing the direction of movement of all solid objects.	27
All living beings have nourishment needs and processes to satisfy these needs.	95
Bodies of all living beings are composed of natural substances.	84
All living beings grow and develop over time.	82
All living beings produce offspring that are similar to them.	58
All animals have goals, and they take actions to satisfy those goals.	57
All animals are self-propelled.	41
All mental beings can perceive the world through their sensors.	67
All mental beings have beliefs and desires.	62
All mental beings have self-awareness.	58
All mental beings have emotions.	55
All mental beings understand and speak languages to communicate with others.	28
Superheroes can fly through the air.	56
Superheroes can leap over skyscrapers.	51
Superheroes can see through walls.	42
Superheroes can hear whispers from miles away.	37

Superheroes can become invisible.	29
Superheroes can walk through walls.	22

The results show that a significantly larger percentage of participants agreed than disagreed with each statement. Of the statements derived from Barrett's Table 1, even in the case of the least supported statement ("physical contact is required for launching or changing the direction of movement of all solid objects"), 60% of the participants agreed with the statement while only 33% disagreed. This lends support to Barrett's (2008) claim that people hold these expectations about these categories. However, large differences in support for these statements—ranging from 95% for the most supported statement ("all living beings have nourishment needs and processes to satisfy these needs") to 27% for the least supported statement—supports the context-based view which posits a continuum of expectation values.

One limitation of confirmation studies, such as Experiment 1, is that they do not allow us to explore the entire mental space of the participants to find out what other concepts are related to the concepts of interest. Category norming studies (McRae, Cree, Seidenberg, & McNorgan, 2005) which ask participants to list all the concepts that are related to a given concept suggest a fruitful way to elicit semantic fields of concepts. This is the method we employed in the next study.

3 Experiment 2

Replicating the free association methodology used by category norming studies (McRae et al., 2005), we presented participants with categories of "a solid object," "a living thing," "an animal," "a mental being," and "a super-hero" and asked them to list as many of each category's properties as they could think of.

3.1 Participants

One hundred and fifty adult male and female participants were recruited using Amazon's Mechanical Turk, for a small reward for answering the survey questions.

3.2 Materials & Procedures

The materials consisted of online forms with each category name followed by a text field in which participants typed in as many properties of the category as they could think of. Participants were advised to take as much time as they needed to complete the exercise.

3.3 Results and Discussion

The participant responses were coded using a two-step process. The first step involved creating semantically similar categories for category features. Thus, the following four participant responses as to features for the category "a solid object," that is,

- "is weighty",
- "is heavy",
- "weighs a lot", and
- "has weight,"

were all put into one feature labeled "is heavy." Once the most representative feature labels had been created, the second step was carried out. This involved assigning a 1 if the participant was judged to have indicated the feature and assigning a 0 otherwise. Each category feature was assigned a weight by computing the average coded value. Thus, a category feature that was indicated by all 150 participants would be assigned a value of 1, and a feature not mentioned by any participant would be given a zero weight. The category features were ranked by weight from the most prevalent to the least prevalent.

The features our participants most commonly listed for the concept "a solid object" are graphically shown in Figure 1. The percentage of participants who listed a feature is indicated as the strength of the connection between that feature and the concept in question. Only half of the features from Barrett's list—namely *tangibility* ("can be touched," mentioned by 14% of the participants), *visibility* ("is visible," mentioned by 9%), and *solidity* ("is solid," mentioned by 7%)—made the list of features mentioned by our participants; *cohesion*, *contact*, and *continuity* were not mentioned. Furthermore, the three features most commonly mentioned by participants were not included by Barrett (2008). These are *hardness*, *heaviness*, and *having a mass*.

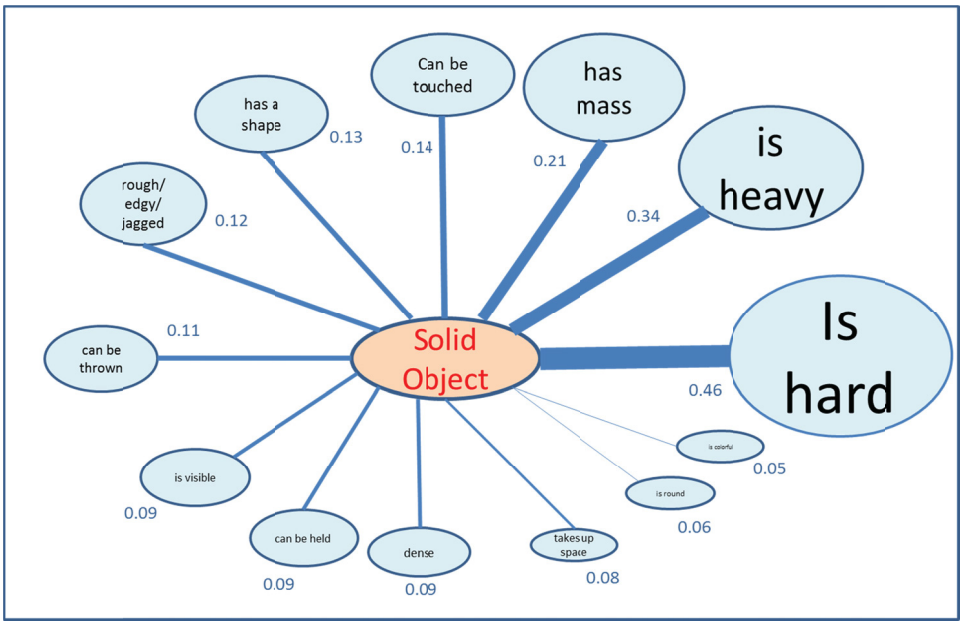

Figure 1: Most commonly mentioned features of the category "a solid object." The number beside each node represents the proportion of participants who mentioned the given feature.

The features our participants most commonly listed for the concept "a living thing" are graphically shown in Figure 2. The results show that our participants endorsed four of the features mentioned by Barrett (2008), namely, *nourishment* ("can eat," mentioned by 25% of participants), *reproduction* ("can reproduce," mentioned by 22%), *growth* ("can grow," mentioned by 14%), and *vulnerability* ("can die," mentioned by 11%). None of the participants mentioned *natural composition*, *kind-specific essence*, or *parts-serving-the-whole* features. In addition, the most commonly mentioned feature of *breathing* was not listed by Barrett (2008). This may be because not all living things actually breathe, but that is beside the point. Work on naïve/folk psychology has shown that people's intuitive expectations do not always correspond to scientifically defendable notions (Gopnik & Meltzoff, 1997). Other, less frequently mentioned features also missing from Table 1 include *moves/walks/runs* (19% of participants) and *is alive* (16% of participants).

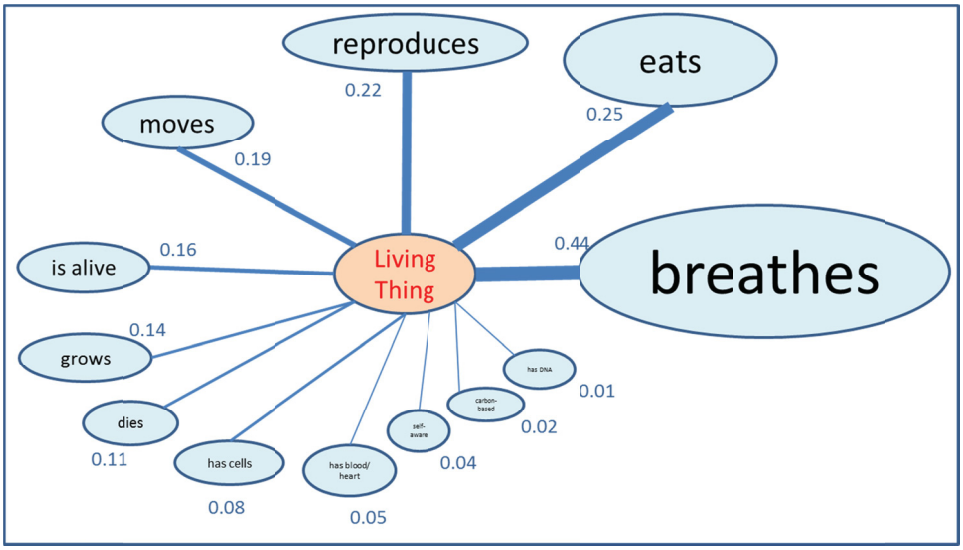

Figure 2: Most commonly mentioned features of the category "a living thing." The number beside each node represents the proportion of participants who mentioned the given feature.

Figure 3 shows the features most commonly listed by our participants for the concept "an animal." The results show that while a significant number of participants (30%) mentioned some type of movement (*walking*, *running*, or *moving*), only one participant explicitly listed *self-propelled* ("moves on its own") as a key feature of being an animal. The second feature listed by Barrett (2008)—namely, *goals*—was not mentioned by any of our participants (nor were any of its synonyms: *purpose*, *objective*, or *aim*). On the other hand, the features most commonly mentioned by our participants—namely, "eats food" (63%), "is alive" (47%), and "breathes" (32%)—are not included by Barrett in Table 1 as key features of *animacy* (although *nourishment* is listed as a key feature of *biology*, a superordinate category of *animacy*).

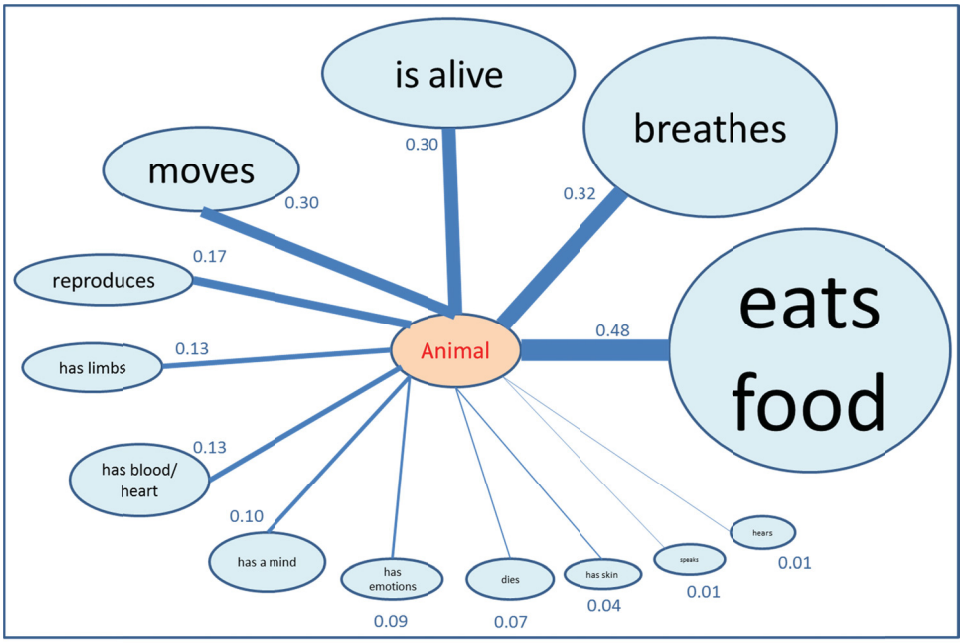

Figure 3: Most commonly mentioned features of the category "an animal." The number beside each node represents the proportion of participants who mentioned the given feature.

The features mentioned most commonly for the concept "mental being" are shown in Figure 4. It shows that only a small number of our participants listed the three features mentioned by Barrett (2008):

- *self-awareness* ("is self aware/conscious"), mentioned by 8% of participants;
- *understand language and communication* ("can perceive" and "can talk," mentioned by 9% and 8% of participants, respectively); and
- *reflective and representational mental states* ("has beliefs/desires"), mentioned by 6% of participants.

Furthermore, none of the top features mentioned by our participants—"thinks" (72%), "is human" (23%), "is an animal" (19%), "has emotions" (19%), "is smart" (15%), "is alive" (13%), and "has a mind" (12%)—are included by Barrett (2008).

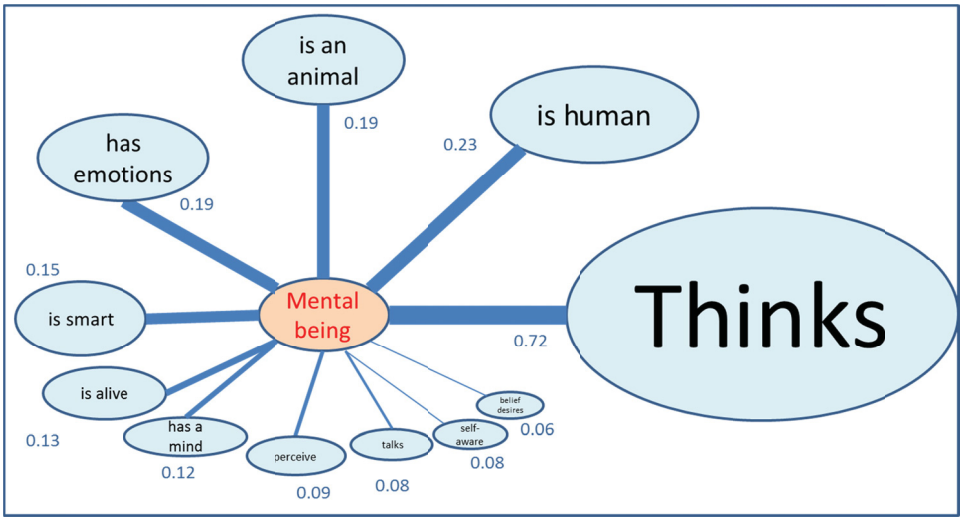

Figure 4: Most commonly mentioned features of the category "a mental being." The number beside each node represents the proportion of participants who mentioned the given feature.

Finally, Figure 5 shows the features our participants mentioned most frequently for the concept "superhero." This category was not considered by Barrett (2008). The results show that while superheroes have some human properties like "being strong," "rescuing good people," "being good," and "helping people," they also have a number of non-human properties such as "having a superpower," "fighting evil," and "being able to fly."

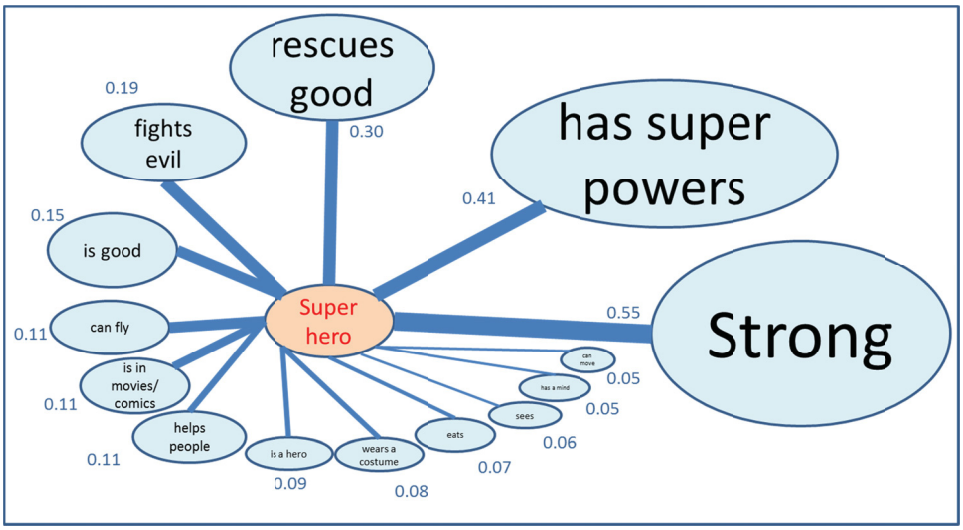

Figure 5: Most commonly mentioned features of the category "a superhero." The number beside each node represents the proportion of participants who mentioned the given feature.

While a majority of participants agreed that mental beings think, animals eat food, and superheros are strong, even the most prevalent features for the categories "a solid object" and "living thing" were mentioned by only a minority of participants. This may have been due to the fact that these

categories are too abstract. McRae et al. (2005) had found that their participants had trouble generating features for categories that were too abstract. We attempted to address this shortcoming in the following experiment.

4 Experiment 3

The purpose of Experiment 3 was to elicit participant responses to instance categories that were more concrete than the abstract categories used in Experiment 2.

4.1 Participants

Participants included 153 adult males and females who completed the study online through Mechanical Turk, for a small remuneration. Three participants failed the attention check question (the question asked participants "please do not click here") and thus were excluded from all subsequent analysis.

4.2 Materials & Procedures

The material and procedure were the same as Experiment 2 with the category list revised to

- "a rock" (instance of "a solid object"),
- "a deer" (instance of "an animal"),
- "a person" (instance of "a mental being"),
- "a superman" (instance of "a superhero"), and
- "a ghost" (instance of "an ethereal being").

4.3 Results and Discussion

The results were coded using the two-step coding procedure used in Experiment 2. The results are shown in Figure 6 to Figure 10. They show that a majority of participants agreed on the feature *hard* for the category "rock." A minority of participants in Experiment 2 had also found "is hard" to be the most prevalent feature of the more abstract category "a solid object." As well, participants listed additional features—e.g., "has minerals," "is round/smooth," "used to build things," "gray" in the case of "rocks," and "has hands/feet," "has eyes/ears," and "has heart/blood" in the case of "person"—that are not salient features of their superordinate categories. A majority of participants found that "a superman" "flies." Almost half the participants also agreed that "a person" "has a mind" and "a ghost" "is scary/spooky."

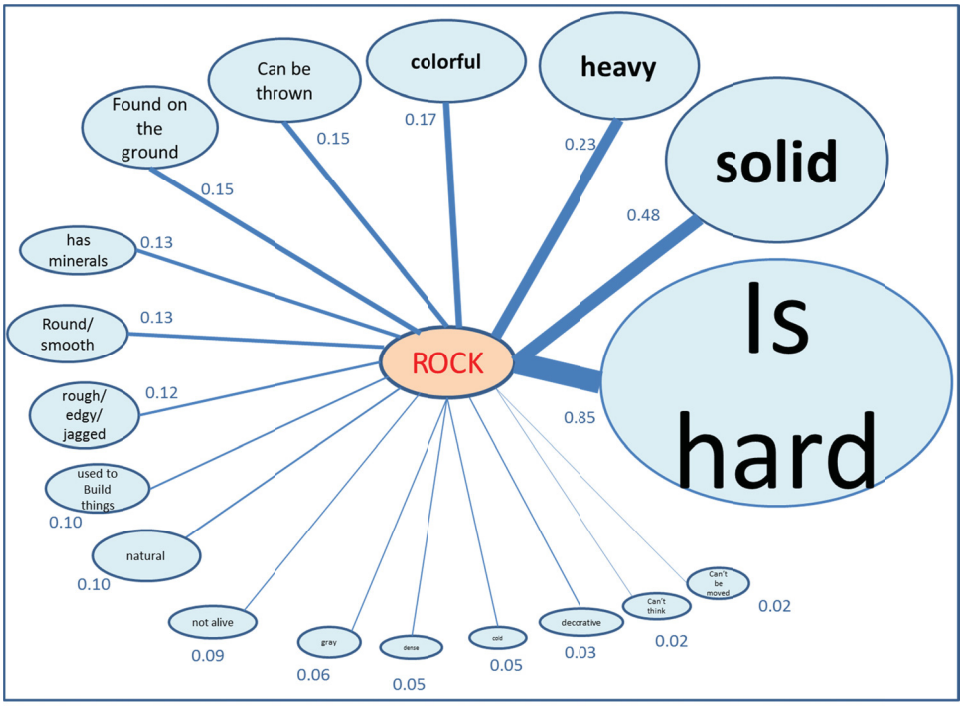

Figure 6: Most commonly mentioned features of the category "a rock." The number beside each node represents the proportion of participants who mentioned the given feature.

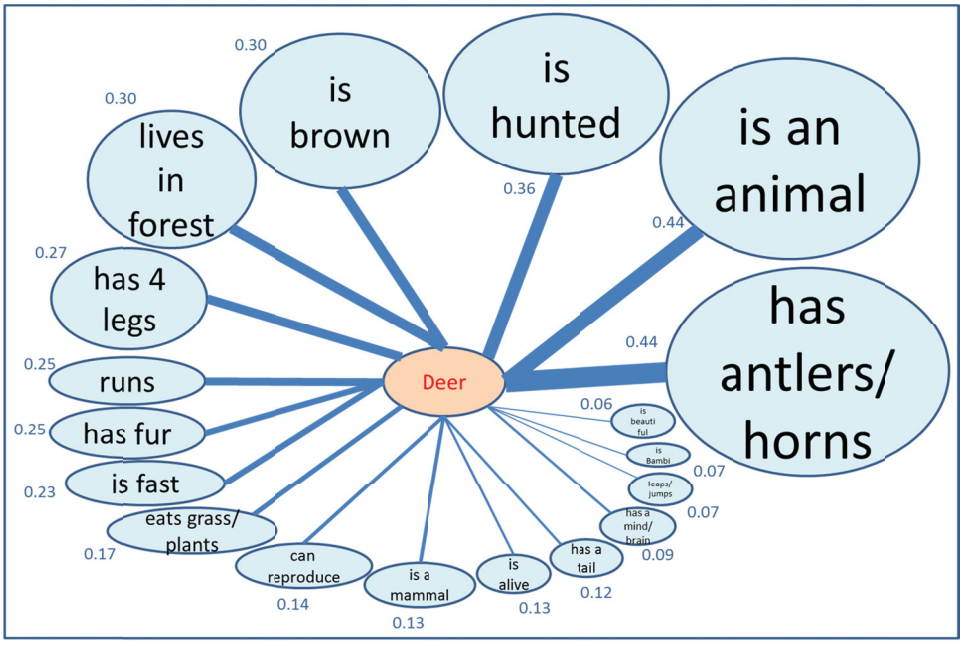

Figure 7: Most commonly mentioned features of the category "deer." The number beside each node represents the proportion of participants who mentioned the given feature.

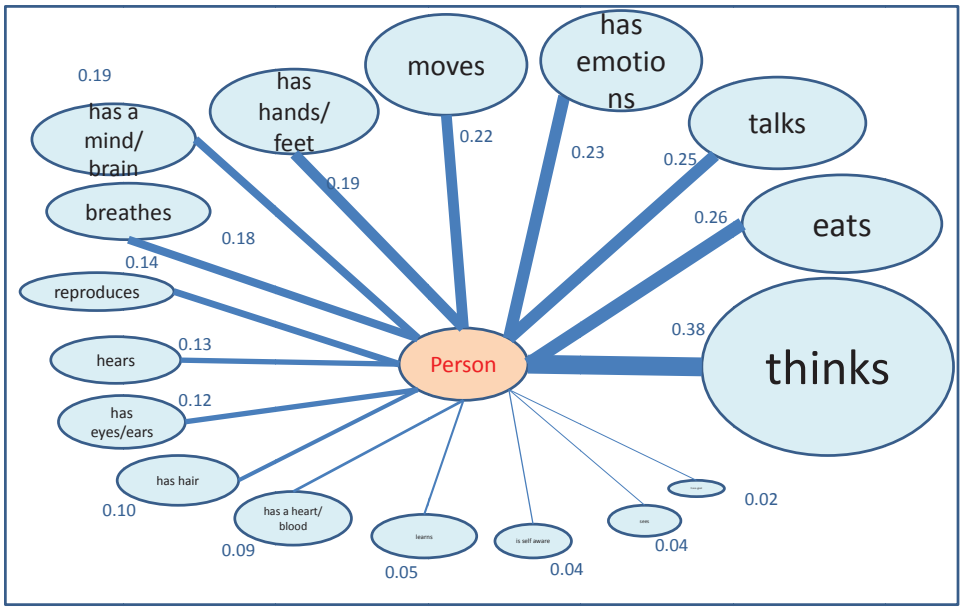

Figure 8: Most commonly mentioned features of the category "person." The number beside each node represents the proportion of participants who mentioned the given feature.

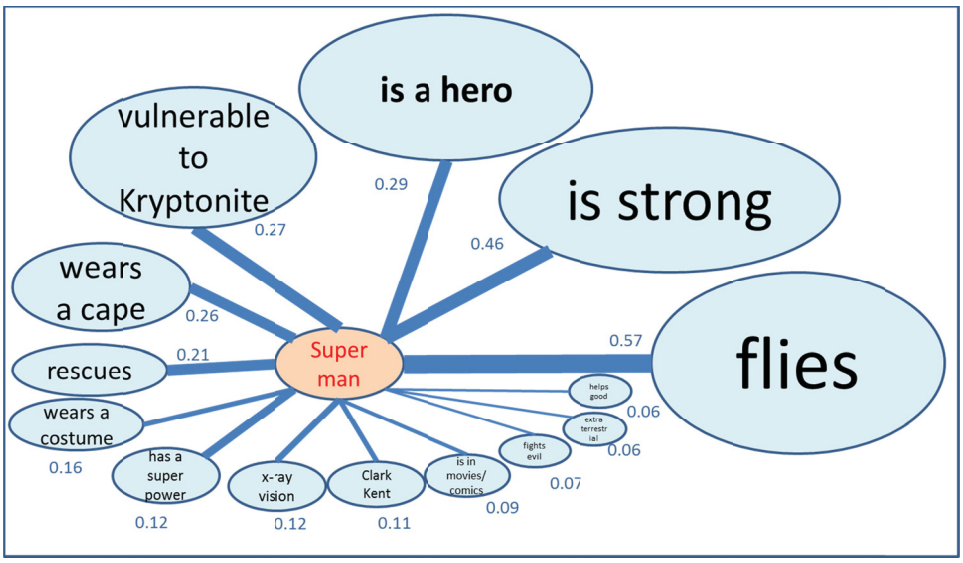

Figure 9: Most commonly mentioned features of the category "superman." The number beside each node represents the proportion of participants who mentioned the given feature.

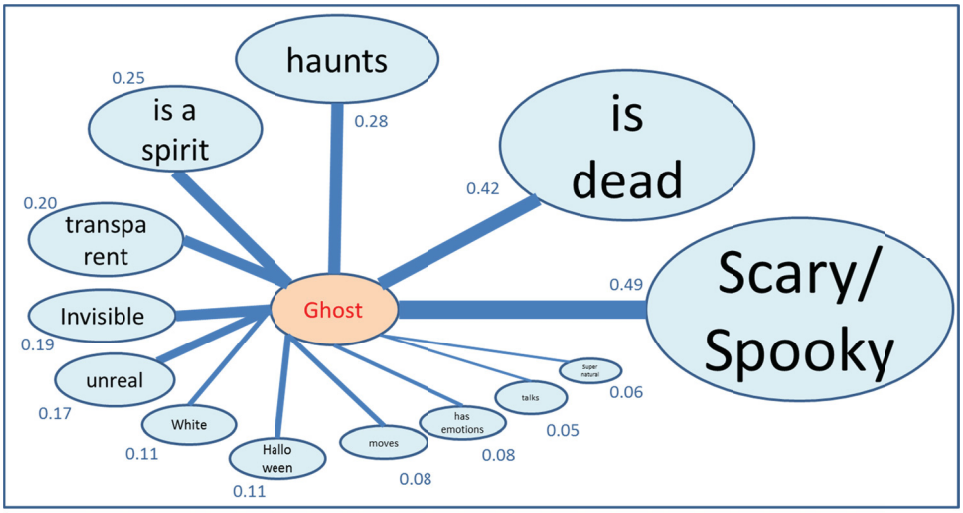

Figure 10: Most commonly mentioned features of the category "ghost." The number beside each node represents the proportion of participants who mentioned the given feature.

5 General Discussion

The results of Experiment 1 suggest that our participants offered varying degrees of support to the propositions derived from Barrett's (2008) table of intuitive expectation sets. In Experiments 2 and 3, when participants were allowed freer choice, the features that came to their minds most frequently were sometimes different from those handcrafted by Barrett (2008). According to a spreading activation model of memory, the concepts that are activated most frequently when a concept is mentioned are most strongly related to it in people's semantic memory. According to the context-based model, the relationships among concepts in people's semantic memory underlie their intuitive expectations. Thus, the results of Experiments 2 and 3 should help us formulate intuitive expectation sets for the concepts "a solid object," "a living thing," "an animal," and "a mental being." These expectation sets are listed below in Table 3.

Table 3: Revised intuitive expectation sets.

Concept	Properties
Solid objects	Are hard, rigid, and firm.
	Are heavy (i.e., they have a weight).
	Have a mass.
	Are tangible (they can be touched, they have a shape, and they can be thrown).
	Are visible (they can be seen).
Living things	Breathe.
	Eat food/nourish themselves.
	Reproduce (like begets like).
	Are able to move.
	Grow and develop.
	Are vulnerable to injury and death.
Animals	Have limbs (hands and legs).

	Have blood and a heart.
	Have a mind.
	Have emotions.
Mental beings	Think (reason/reflect/have thoughts).
	Are human.
	Are animals.
	Are smart/intelligent/rational.
	Can perceive the world.
	Are self-aware/conscious.
	Talk to other mental beings.
	Understand language and communication.

6 Conclusions

The studies reported here were carried out to empirically study Barrett's (2008) notion of intuitive expectation sets as a coherent set of expectations that are strongly correlated with each other. The studies validate some aspects of Barrett's handcrafted list of intuitive sets and suggest changes to others. We believe that this work will not only allow cultural scientists to better understand the spread of non-natural and religious concepts but also allow the CAF's influence activities practitioners to design messages that are more memorable for their target audiences.

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List of symbols/abbreviations/acronyms/initialisms

CAF	Canadian Armed Forces
DND	Department of National Defence
DRDC	Defence Research and Development Canada
MCI	Minimally Counterintuitive
PI	Principal Investigator
R&D	Research & Development

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This report presents the results of a series of studies carried out to understand people's mental representation of common concepts. The results support some aspects of previous research and question some previous assumptions. This work will not only allow cultural scientists to better understand the spread of non-natural and religious concepts but also allow the Canadian Armed Forces's (CAF) influence activities practitioners to design messages that are more memorable for their target audiences.

Le présent rapport fait état des résultats d'une série d'études qui visent à comprendre la représentation mentale de concepts courants. Les résultats viennent corroborer certains aspects de travaux de recherche antérieurs et remettent en question quelques-unes des hypothèses antérieures. Ces travaux permettront non seulement aux scientifiques des cultures de mieux comprendre la diffusion des concepts non naturels et religieux, mais également aux professionnels du marketing et aux praticiens des activités d'influence des FAC de concevoir des messages qui seront plus mémorables pour les publics cibles.

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Information/Influence Operations; IO Message Design; Memory for Counterintuitive concepts

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