The conceptual representation of science and implications for psychology's status as a scientific
discipline

by

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CONCEPTUAL REPRESENTATION OF SCIENCE AND PSYCHOLOGY

Abstract

Research has shown that people are skeptical of psychology's status as a science (Lilienfeld, 2011). The current research aimed to determine whether skepticism towards psychology is rooted in the way people process categorical information. This was achieved by investigating the category *science* using the family resemblance approach. The results of two experiments showed that chemistry, physics, engineering, and neurology were conceptually the most typical sciences. Unexpectedly, psychology's typicality scores were found to be close to those of these disciplines. Nonetheless, people's representation of science showed a clear distinction between the natural and the social sciences. Psychology did not elicit the characteristic features of the more typical sciences (i.e., the natural sciences). These results may indicate that categorization behavior is the cognitive mechanism responsible for the perception that psychology is unscientific. The possibility that people use stereotypes rather than deliberate consideration of the scientific method to make judgments about science is discussed.

Keywords: conceptual representation, science, psychology, typicality, family resemblance.

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The conceptual representation of science and implications for psychology's status as a scientific discipline

The scientific method has proven to be a highly successful procedure for acquiring knowledge, and it has been widely applied to explain how the world works. Thus, it is no surprise that science is highly regarded by the general public (Chalmers, 2013) and people believe that it can help answer many of the problems facing the world in the 21st century (Eurobarometer 419, 2014). These favorable representations of science are very important, especially when considering that science requires the public's approval to promote, develop, and apply its findings (Durant, Evans & Thomas, 1989). Nonetheless, some disciplines that employ the scientific method are not regarded as sciences. In particular, the social sciences are perceived less favorably than the natural sciences, and psychology is no exception (Lilienfeld, 2011).

Psychology is generally regarded as an unscientific discipline by the general public (Ferguson, 2015; Lilienfeld, 2011; Stanovich, 2013). Unfortunately, this perception has been enduring. For example, in the 1980s, David Stockman, President Reagan's Director of the Office of Management and Budget, derided psychology as a pseudoscience when justifying his administration's plan to reduce funding for behavioral science at the National Science Foundation (Benjamin, 2003). In 2008, an APA Benchmark study found that only 30% of participants "agreed that psychology attempts to understand the way people behave through scientific research," (Penn, Schoen & Berland Associates, 2008, p. 29). More recently, a microbiologist and Los Angeles Times journalist Alex Berezow (2012) wrote that psychology is not a science because it does not adhere to its defining criteria including quantifiability and controlled experimentation. The public's perception of psychology as a science is an important issue considering that it influences

social and political decisions regarding the distribution of funding and the implementation of its findings in the “real world” (Benjamin, 2003).

Skepticism towards psychology’s scientific status is clearly misguided. For instance, Gauch (2003) argued that science is defined by its proponents’ epistemological beliefs and their use of systematic empiricism. Psychology’s use of systematic empiricism is clearly laid out in any book on research methods for the discipline (see Gravetter & Forzano, 2015; Rosnow & Rosenthal, 2008; Shaughnessy, Zechmeister, & Zechmeister, 2000). Moreover, scientific epistemological beliefs such as the need of falsifiable hypotheses or the importance of the replicability of findings are noticeable across psychological research. Considering that psychology meets these criteria (at least as well as other natural sciences, see Chalmers, 2013 for challenges associated with establishing the scientific status of physics), then it is clearly a science. Hence, it is not immediately clear why psychology is perceived so differently than biology, chemistry, and physics. One possible hypothesis is that there may be a cognitive bias influencing the public’s perception of psychology as an unscientific discipline. Different lines of research suggest this possibility.

First, empirical research has shown that psychology is not perceived in the same way as other scientific disciplines. For example, in a study about the stereotyping of science, Krull and Silvera (2013) found that participants rated the equipment employed in the natural sciences (e.g., microscopes) to be more scientific than equipment used in the behavioral sciences (e.g., questionnaires). The same study showed that disciplines that were judged to be less scientific were also judged to be less important. Relatedly, in a study about the public’s image of psychology, Hartwig and Delin (2003) asked their participants to rate the extent to which six types of professionals (teacher, lawyer, general practitioner, psychiatrist, nurse and psychologist) were needed. They also asked their participants to evaluate these professions on a variety of positive

and negative adjectives (e.g., friendly, intelligent, bossy, and arrogant). This latter more indirect measure suggested that psychologists were seen fairly positively. Yet, the participants rated psychology as the least needed profession. Finally, Janda, England, Lovejoy, and Drury (1998) found that participants rated psychology's contributions to society as being much less important than those of biology, chemistry, physics, medicine, and economics.

Secondly, various experiments have found that psychological phenomena are mistakenly perceived to be easier to understand than natural science phenomena. For instance, Zimmerman Gerson, Monroe, and Kearney (2007) asked junior-high, high school, and college students to read passages in four academic disciplines: biology, chemistry, physics, and psychology. The students then answered questions about these passages and provided confidence judgments about their ability to answer them correctly. Whereas older students progressively became more underconfident when evaluating their ability to answer questions about chemistry and physics, all students were greatly overconfident about their ability to answer questions about psychology. Thus, they thought that psychology questions were easier to answer than they actually were. Keil, Lockhart, and Schlegel (2010) obtained a similar result. They found that children (grades 2 to 8) rated psychological phenomena as being easier to explain than phenomena studied in the natural sciences. They also found that children rated questions within psychology that included a neuroscience component to be more difficult than those in other psychological domains (e.g., cognitive psychology). Thus, even within psychology, children perceive domains closer to the hard sciences (e.g., neuroscience) as more difficult than those closer to soft sciences.

Finally, empirical evidence suggests that superficial features of neuroscience influence perceptions and judgments surrounding behavioral research. For example, Weisberg, Keil, Goodstein, Rawson, and Gray (2008) showed that poor explanations of psychological phenomena

were judged more favorably when they included neuroscientific terminology. It seems as though even irrelevant neuroscientific information plays an influential role in people's judgments about scientific reasoning. Additional research has found similar results. For instance, Ikeda, Kitagami, Takahashi, Hattori, and Ito (2013) found that texts that included a brain image were evaluated as more credible and produced a higher subjective rating of comprehension than texts without the inclusion of brain images. Considered jointly, all these findings provide strong evidence that psychology is perceived differently than other scientific disciplines. They also suggest that the instruments, terminology, and images used by the "hard" sciences are perceived to be more positive, important, difficult, and scientific than those used by "soft" sciences. To explain these perceptions, an examination of the underlying cognitive processes involved in people's perceptions of science and psychology is warranted.

An obvious starting point for this research is the categorization literature (Murphy, 2002). If, as proposed by Krull and Silvera (2013), superficial features influence people's judgments about what is scientific, then perceiving psychology as unscientific could be explained by the cognitive process involved in categorization behavior. The process of categorization involves a comparison of features of instances to those associated with different concepts (Murphy, 2002; Smith & Medin, 1981). Membership assessment is intimately related to the number of features shared between a given exemplar and the other members of the category. While some features will be shared by most members of a category, others will be associated with very few members. The extent to which the features possessed by a given member overlap with those of other members of a category is called family resemblance (Rosch & Mervis, 1975).

Family resemblances among members of a given category influence the typicality of each member. A large number of overlapping features accounts for high family resemblance scores and

high typicality ratings. The more typical members (or “good” members) of any category are thought of more rapidly, with greater ease, and more frequently than atypical ones (Murphy, 2002). This theory explains why in North America, a Robin is a more typical member of the category *bird* than a penguin. The features associated with the category *bird* includes *two wings, feathers, flies, perches in trees*, and so on (Murphy, 2002). Hence, a Robin is a more typical bird than a penguin because it has more features that overlap with the main features of the category *bird*. If superficial features of the academic disciplines (i.e., instruments, terminology, or images) influence people’s judgments about what is scientific, then a typicality approach could be used to explain why superficial differences among disciplines influence the extent to which people judge them to be scientific.

The present research will aim to discover people’s representation of science to determine whether categorization behavior is biasing the perception of psychology as unscientific. Thus, I will explore whether psychology is an atypical member of the category *science* and will use a family resemblance approach to address this question. Family resemblance is perhaps the most widely used and cited method to measure typicality (Saunders, Tax, Ward, & Loken, 1991). It has been used extensively to understand categorization behavior in many different research domains, including concept formation (Rosch, 1973), semantic memory (McRae, Cree, Seidenberg, & McNorgan, 2005), consumer product classifications (Saunders et al., 1991; Hoek, Van Boekel, Voordouw & Luning, 2011), and social power structures (Haugaard, 2010). Family resemblance provides a means to examine people’s psychological representations of science.

Accordingly, my proposed experiments will aim to accomplish several goals. First, I will explore the content of the semantic domain consisting of scientific disciplines according to people’s perceptions to determine whether psychology occupies a significantly different semantic

space than the other scientific disciplines. Secondly, I will investigate the internal structure of the category *science* to explore whether family resemblance scores establish psychology as an atypical member of this category. Third, I will analyze the role of the variable “perceived difficulty” in the typicality of the sciences and the representation of psychology.

To achieve these goals, I will first provide a detailed discussion of psychology’s scientific status and the public’s misconceptions about it. Next, I will argue that perceived differences among the scientific disciplines could explain this phenomenon. Particularly, I will present research that shows that superficial differences among disciplines influence people’s judgments. Then, I will outline the literature surrounding categorization behavior and demonstrate how it can be used to explain the public’s skepticism towards psychology’s scientific status.

Scientific psychology

Science is a method devised to acquire and accumulate knowledge (Gauch, 2003). However, a monolithic scientific method does not exist (Bauer, 2009; Chalmers, 2013) and this fact makes the precise nature of science difficult to discern. Science is multifaceted and scientific disciplines are diverse. Depending on their object of study, scientific methodologies require diverse procedural adaptations. Sometimes, this can cause differences in opinion regarding their effectiveness (Irzik & Nola, 2011). For example, the concept of operationalization refers to the process by which a clear relationship between theoretical constructs and its measurement is established (Campbell, 1920). The operationalization of scientific notions is essential in enabling experimental evidence to bear on scientific propositions (Machery, 2007). In physics, some examples of these constructs are atoms and gravity. Research in psychology meets the criteria of operationalization by quantifying psychological constructs via external factors and behaviors. For instance, a personality dimension such as neuroticism is a theoretical construct that can be

measured with a questionnaire (e.g., Maudsley Medical Questionnaire, Eysenck Personality Inventory, etc.). Additionally, methods in psychology address the extent to which the operationalization of a theoretical construct actually corresponds to the relevant theoretical concept (see construct validity, Cronbach & Meehl, 1955). However, despite the fact that psychology uses a scientific methodology, it is easy to find disagreements about its scientific status even among scientists (see Berezow, 2012).

Although there are different methodological approaches, the scientific method is marked by a willingness to root out erroneous beliefs and a desire to address possible errors with procedural safeguards (Lilienfeld, 2011). Psychology also meets this criterion for science (at least as well as other sciences). For example, researchers use procedures such as randomization, control groups, blind observations, and inferential statistics to minimize the probability that incorrect conclusions are drawn from research (e.g., distinguishing a genuine covariation from an illusory correlation, Chapman & Chapman, 1967). Nevertheless, neither psychology nor other scientific disciplines are exempt from error (Chalmers, 2013). One may ask then what will determine a discipline scientific.

The concept of demarcation is key to distinguishing science from pseudoscience. Popper (1963) argued that falsifiability is what determines the scientific status of a theory. A scientific theory is falsifiable when empirical observations have the potential to allow a theory to be proven false. Because hypothesis testing relies on the logic of the conditional statements, scientific theories can never be proven to be true. They can be falsified or, at best, they can avoid falsification. In fact, the more a theory resists falsification attempts, the more the scientific community's confidence in it will grow. Certainly, theories from psychology meet Popper's requirement of falsifiability. For instance, a historically important theory in cognitive psychology that was tested empirically and was then shown to be false was the modal model of memory

(Atkinson & Shiffrin, 1968). This model stated that information processing involves different kinds of memory, two of which are short-term memory and long-term memory. Short-term memory refers to “the capacity of holding a small amount of information in mind in an active, readily available state for a short period of time” (Wang & Wets, 2012, p. 43). Long-term memory refers to the unlimited capacity memory store that can hold information over lengthy periods of time. The modal model made many strong predictions including this one: learning is a function of the time that a piece of information spends in short-term memory. In other words, it suggested that repetition was the key process that initiated and facilitated the transfer of information into long-term memory. This prediction was tested empirically and falsified (e.g., Tulving & Osler, 1968). Research eventually showed that the extent to which people engage meaningfully with material enhances memory, but not repetition per se (Brown, Roediger, & McDaniel, 2014). Thus, this example illustrates that psychology adjusts its understanding of natural phenomena via hypothesis testing as the other sciences do.

While the literature agrees that the criterion of falsifiability is necessary to distinguish science from pseudoscience, it has been claimed that it is not sufficient. According to Lakatos (1978), “the hallmark of scientific behavior is a certain degree of skepticism towards one's most cherished theories. Blind commitment to a theory is not an intellectual virtue; it is an intellectual crime” (p. 1). These thoughts explain why he identified critical thinking with the scientific attitude and a dogmatic disposition with a pseudo-scientific one. A dogmatic attitude is clearly related to the tendency to confirm scientific theories, “even to the point of neglecting refutations, whereas the critical attitude is one of readiness to change them” (Popper, 1963, p. 26). Consequently, these considerations bring to light the importance of the reproducibility of findings for science. Once again, psychology satisfies this criterion. For example, it is clearly a critical attitude that guides

psychological research such as the recent study that aimed to replicate 100 experiments in two top-tier journals (Open Science Collaboration, 2015). If psychology applies the scientific method (as can be corroborated in any book in research method in psychology, e.g., Gravetter & Forzano, 2015; Rosnow & Rosenthal, 2008) and if psychological theories meet the criteria of falsifiability and reproducibility, then why is it the case that psychology is perceived to be unscientific?

Misrepresentations of psychology

Different causes for the public's skepticism towards psychology's scientific status have been proposed. For instance, psychologists are not typically thought of as scientists (Benjamin, 2003). Lilienfeld (2011) proposed that perhaps confusion between psychologists and psychotherapists one possible reason for the fact that many laypersons regard psychology as a helping profession rather than a scientific one. This possibility is further supported by Stanovich's (2013) observation that the public face of psychology is not represented by researchers or scientifically minded psychotherapists. Instead, it is represented largely by media celebrities (e.g., American personalities such as Dr. Phillip McGraw "Dr. Phil" or Dr. Laura Schlessinger "Dr. Laura").

Another cause for the misrepresentation of psychology as unscientific could be that certain cognitive biases influence the public's perception of psychology. For example, the hindsight bias (or the "I knew it all along" effect) could explain why when people first learn of a psychological finding, it frequently appears self-evident (Gage, 1991; Kelley, 1992; Myers, 1994). Another bias that could also be playing a role in the public's skepticism of psychology's unscientific status is an illusion of understanding. In a survey, Wood, Jones, and Benjamin (1986) found that 83% of respondents believed that everyday life experiences give them appropriate training in psychology. In summary, although some causes for the skepticism towards psychology's scientific status have

been proposed, concrete empirical evidence to understand the cognitive mechanisms underlying the issue are still left to be determined.

Perceived differences among scientific disciplines

Empirical evidence suggests that the superficial features of academic disciplines can alter people's perception of scientific research. This fact suggests that the categorization literature could provide a useful framework to explain the cognitive mechanisms underlying the public's perception of psychology. For instance, in a study about the stereotyping of science, Krull and Silvera (2013) sought to determine whether the content of research influences judgments about whether a given type of research is considered to be scientific. They asked participants to judge how scientific they found different topics to be (e.g., atomic structure, emotions, and cognition), how scientific they believed certain equipment used within science were (e.g., microscopes, questionnaires, and test tubes), and how scientific scenarios combining a variety of topics and equipment associated with different scientific disciplines were (e.g., "Dr. Davis studies attitudes. To do this research, Dr. Davis uses photographs"). Additionally, they asked participants to rate how important they believed these research scenarios were. They found that participants rated both natural science topics and equipment to be more scientific than behavioral science topics and equipment. They also found that participants judged scenarios combining natural science topics with natural science equipment to be the most scientific and most important. Krull and Silvera argued that psychology may have been viewed as less important because it investigates topics and employs equipment that are dissimilar to those more typically perceived to be scientific.

The categorization literature suggests that categories are organized around a set of properties or a group of features that are characteristic of category membership (Rosch, 1975). Krull and Silvera's (2013) experiments may provide evidence to suggest that the characteristic

features of science are the same as the characteristic features attributed to the natural sciences (e.g., chemistry, biology, and physics). Perhaps, it may be that the natural sciences are the most typical members of the category *science*. Their findings also indicate that the characteristic features attributed to science may be different from those attributed to psychology. The latter could mean that psychology is viewed as an atypical science, and it could help explain why people are biased to perceive psychology as unscientific.

Analogously, research has shown that psychology is generally misrepresented as being a discipline with concepts that are a lot easier to comprehend than those of the natural sciences. Zimmerman et al. (2007) asked students to read text passages as if they were studying for an exam. Then, students were asked to provide a confidence judgment indicating their perceived ability to answer questions about the text. Finally, students were asked to answer questions that assessed their overall comprehension. Zimmerman et al. found that students were overconfident when they read psychology texts, but underconfident when they read chemistry and physics. Zimmerman et al. (2007) argued that students' conceptions about the different disciplines were based on their reputations. For example, physics is perceived to be hard, while psychology is perceived to be easy. Thus, they thought that psychology questions were easier to understand than they actually were. Therefore, I would argue that research exploring the typicality of the different sciences and the role of perceived difficulty on the representation of science would provide empirical evidence to support Zimmerman et al. claim. Moreover, it would show that categorization behavior is the cognitive mechanism behind the observed biases on scientific reasoning.

In a related line of research, Keil et al. (2010) found that children also believe that psychological phenomena are less difficult to understand than those from other natural science phenomena. In their experiments, they asked children to rate how difficult it was to understand

everyday phenomena in chemistry, physics, biology, economics, and psychology (e.g., Why is it that magnets pull on iron but not on glass? Why are gas prices different in different parts of the country?). All phenomena had been equated for actual difficulty with a sample of adults. Keil et al.'s results showed no significant differences among judgments of difficulty about the three natural sciences (i.e., physics, chemistry, and biology). However, children judged natural science phenomena to be more difficult to investigate than psychological phenomena. Moreover, neuroscience phenomena were perceived to be more difficult than phenomena studied within cognitive psychology and social psychology. Keil et al. argued that these findings arose because people tend to explain psychological phenomena using intuitive folk theories of behavior. These theories are much more coherent and comprehensive than those that people hold for physics and biology. Also, Keil et al. argued that people's access to their own psychological states may have misled them to believe that they understood the causes of their behavior. Hence, for these different reasons, people may have incorrectly believed that psychological phenomena are easier to understand than they actually are.

Perhaps the most well-known empirical evidence suggesting that even within psychology, people perceive domains closer to the hard sciences (i.e., neuroscience) more favorably than those closer to the soft sciences was presented by Weisberg et al. (2008). They explored whether irrelevant neuroscience information could interfere with people's ability to critically evaluate the quality of explanations concerning psychological phenomena. Thus, Weisberg et al. asked lay adults, neuroscience students, and neuroscience experts to judge the quality of psychological explanations. Both explanations which were accurate or circular (i.e., good or bad) were presented in two different conditions: with or without irrelevant neuroscience information. Weisberg et al. (2008) found that participants in all three groups judged good explanations to be more satisfying

than bad ones. However, lay adults and neuroscience students judged bad explanations with irrelevant neuroscience information to be more satisfying than good ones.

Weisberg, Taylor, and Hopkins (2015) replicated and extended Weisberg et al.'s (2008) results using a paradigm that was similar to the original. First, they showed that participants were generally successful at selecting a good explanation of a psychological phenomenon except when the bad explanation contained neuroscience and the good one did not. Next, they found that longer versions of the same explanations were judged to be more satisfying than shorter versions. Nonetheless, even after controlling for explanation length, neuroscience articles were still judged to be superior to psychology ones. Finally, they found that explanations with neuroscience jargon (i.e., fMRI scans) were not judged to be superior to those with simple neuroscience terminology (i.e., brain scans). Weisberg et al. (2015) concluded that one possible explanation for their findings was psychology's lack of prestige. They argued that people are generally skeptical about psychology believing that its methods do not make it a "real science". Therefore, being skeptical of psychology's scientific status may influence participants' judgments of psychological explanations. Moreover, they suggested that neuroscience was perceptually closer to the "hard sciences" and therefore regarded as being a more prestigious.

Weisberg et al.'s (2015) prestige hypothesis certainly is reasonable, but it is based on three main claims: people incorrectly believe that psychology is unscientific, the harder sciences are better examples of scientific disciplines, and neuroscience is perceptually closer to the "harder sciences". Unfortunately, Weisberg's et al.'s (2015) experiments do not provide any empirical evidence to support these claims. I believe that a study examining the representation of science and scientific disciplines' typicality could provide this missing evidence, however. If the natural sciences are found to be the most typical scientific disciplines, it would explain why the "harder"

sciences are perceived to be more scientific. Also, a measure of the degree of typicality among the sciences would directly assess the claim of neuroscience being perceived closer to the “hard sciences”. Thus, I believe that a study concerning the typicality of the sciences will provide empirical support for the idea that the neuroscience allure is rooted in the way we process categorical information.

Finally, there is also evidence suggesting that even irrelevant neuroscience imagery can influence people’s judgments of scientific reasoning. For instance, Ikeda et al. (2013) examined the effect of brain images on meta-comprehension judgments of neuroscience research. Participants were asked to read short texts about brain activity. The information was presented with text only, bar graphs, or brain images. Then, the participants were asked to provide judgments of comprehension (i.e., a subjective measure) and they also answered comprehension question (i.e., an objective measure). Ikeda et al. found that the subjective ratings were much better for the texts that included brain imagery compared to those that did not. Comprehension did not improve when brain images were presented, however. Furthermore, their results showed that the text accompanying brain images was associated with higher credibility ratings. Ikeda et al. argued that brain images tend to be preferred by laypeople without offering an explanation for this phenomenon. Once more, it may reasonably be argued that brain imagery is closely associated with the natural sciences and therefore are more typical of science. Thus, this may have led Ikeda et al.’s participants to perceive the texts with brain imagery more favorably.

In summary, the research that I reviewed strongly suggests that categorization behavior can account for people’s judgments of psychology as an easy, unimportant, unscientific, and less credible scientific discipline. Nonetheless, there currently does not exist direct empirical data in the literature to support this hypothesis. Consequently, research on the internal structure of the

category *science* is needed to understand better the cognitive mechanisms responsible for the negative perceptions surrounding psychology's image.

The internal structure of categories

Studies in the internal structure of categories suggest that categories are fuzzy rather than well-defined and that they are organized around a group of features that are characteristic of category membership (Rosch, 1975). Thus, membership in a category is graded rather than all-or-none. That is, in any given category, some members are more typical (or are thought of as "better" members of the category) than others. For example, an apple is considered to be a more typical member of the category *fruit* than a tomato. The more typical members of any category are named faster, learned with greater ease, and easier to categorize compared to atypical ones (Murphy, 2002).

Rosch and Mervis (1975) investigated the internal structures of categories by measuring the characteristic features of the comprising members. They proposed that categories are internally structured into a prototype (i.e., the clearest case or the best example of the category) and that the most prototypical members share more characteristic features with other members of the category than the atypical ones. Therefore, in their experiment concerning the internal structure of categories, Rosch and Mervis's goals were to obtain the distribution of attributes of members of some superordinate natural categories and to observe the relationship between the degree of relatedness among members of the category and the ratings of typicality of them. They named the measure of the relatedness among members family resemblance.

To obtain family resemblance relationships among members of a category, Rosch and Mervis (1975) used a feature listing task. Thus, participants were asked to list characteristics and attributes that they felt were common to ordinary objects (e.g., if the object was a bicycle, they

were asked to list things they have in common like two wheels, pedals, you ride them, and so on). Four hundred undergraduate students listed attributes possessed by 20 exemplars for six common categories (e.g., fruit, furniture, and vehicle). Each subject rated six items, one item from each category. Items were chosen randomly, and each item was rated by 20 subjects. To derive the family resemblance measure, all attributes mentioned by participants were listed. Next, a credit was assigned to an item every time it received an attribute. Two judges reviewed the resulting list and indicated cases in which an attribute was clearly false. These attributes were deleted from the calculations. Next, each attribute received a score, ranging from 1-20 (the number of items that was credited for this attribute). Then, a measure of family resemblance was derived based on the weighted sum of each of the features that had been listed for the item. Finally, the obtained measure of family resemblance was correlated with typicality ratings of the items. To obtain the typicality ratings, Rosch and Mervis asked participants to rate the extent to which an item represented their idea or image of the meaning of the category name on a 7-point scale. Slides of pictures were presented to participants in random order for 30 seconds while participants made their ratings. Means of the ratings of all participants in the experiment formed the basis for ranking the items.

Rosch and Mervis's (1975) results showed a high positive correlation between ratings of typicality and the distribution of an item's features among the other items in the category. Furthermore, the degree of family resemblance (i.e., the measure of overlapping characteristics features among members) proved to be highly correlated with several typicality effects, such as the speed of learning, naming, and categorizing (Murphy, 2002).

Additional support of the explanatory nature of family resemblance to explore the structure of categories was found investigating the semantic space in which the items of any category are embedded. Rosch and Mervis (1975) predicted that items with the greatest family resemblance

scores would fall in the center of a semantic space defined by proximity scaling of similarity judgments between all pairs of items in a category (See also Smith, Shoben, & Rips, 1974). This finding would further support that family resemblance represents the degree of similarity among members of a category. Furthermore, Rosch and Mervis predicted that multidimensional scaling of the similarity judgments would result in a semantic space in which the distance of items from the origin of the space would be determined by their degree of family resemblance. The latter finding would empirically support the idea that items are perceived to be similar to each other due to the attributes or features which they have in common. Therefore, Rosch and Mervis performed multidimensional scaling on all possible pairs of the same items used to calculate the family resemblance scores. The results showed that their predictions were accurate. In all categories, the most typical items appeared to be closer to the center in the scaling solution. Additionally, strong and significant correlations between the degree of family resemblance and the distance of items from the origin in the multidimensional scaling solution were obtained. Thus, Rosch and Mervis's approach represents an effective tool to explore the internal structure of categories and the typicality phenomena.

Another method which can be used to explore the typicality phenomena among members of any category is a free listing task. The free listing technique allows researchers to find pre-existing associative structures in people's mind. Furthermore, it provides a portrait of the relationship among words learned as a result of experience (Nelson, McEvoy & Schreiber, 1998). A free listing task consists of asking participants to name as many members of a category as they can. As Rosch (1975) demonstrated, the frequency and order of mention of the listed instances are correlated with measures of typicality.

In sum, the family resemblance paradigm and its related methodologies have proven to be useful tools to explore the internal structure of categories and have been extensively used to understand categorization behavior in many different areas. For instance, Malt and Smith's (1984) employed a family resemblance approach to explore whether the properties of category members occur independently or in systematic relation to one another. They asked participants to generate all possible properties for members of six categories (i.e., birds, furniture, fruit, flowers, trees, and clothing). Then, a new group of participants was asked to rate how well each property belonged to each category member. These ratings were then used to look for correlations between properties across the members of a category. Malt and Smith found that properties of natural categories occurred in systematic relation to one another rather than independently. That is, people use correlations between features in making major category distinctions. For example, in the category *birds*, it is well known that the features wings, feathers, and beaks occur together. Therefore, any violation to this setting is extremely salient. They also found that, in these cases of salient violations, the property relationships might have important consequences for the typicality ratings of the members in which the violations occur. Finally, they discovered that properties occur in predictable clusters of more than two features. Thus, the methodology developed by Rosch and Mervis (1975) provided a useful tool to explore the internal structure of categories.

Additional research showed that family resemblance is an advantageous methodology to explore how features influence objects' categorizations. For instance, Tanaka and Presnell (1999) used a feature listing task to study the impact of color on object recognition. They hypothesized that color is more likely to affect the recognition of objects that are high in color diagnosticity (e.g., bananas) than recognition of objects that are low in color diagnosticity (e.g., a lamp). To test this prediction, they first asked participants to list three perceived features that described the

objects (e.g., the subjects were told that if the object was a dime, they could list perceptual features such as round, shiny, and small). The subjects were also asked to indicate the color that was most typical of the target object. Then, in a second experiment where the color diagnosticity of the object was varied, participants performed object classification and naming tasks. The results showed that color information influenced the recognition of high in color diagnosticity objects and that it did not affect the recognition of low in color diagnosticity objects. Thus, the methodology developed by Rosch and Mervis (1975) provided a useful tool to explore the way in which features influence the categorization of items. Other examples where the family resemblance paradigm has proven to be a useful method includes research on concept formation (Rosch, 1973), semantic memory (McRae et al., 2005), consumer products classifications (Hoek et al., 2011), and social power structures (Haugaard, 2010).

Family resemblance is the most widely used and cited measure of how attribute sharing relates to typicality (Saunders et al., 1991). Accordingly, multiple alternatives to calculate family resemblance have been developed, and modifications to Rosch and Mervis's (1975) methodology have also been proposed. For example, Rosch and Mervis used a judging system to determine whether the features listed by participants were appropriate. More specifically, they allowed judges to completely eliminate listed features that they believed did not belong to a given member. Additionally, they allowed judges to add features that participants did not list, but that they considered to be representative of the member (as long as the added feature was previously mentioned for other member of the category). It has since been argued that this judging process may introduce bias to the family resemblance measure (Malt & Smith, 1984; Saunders et al., 1991). Finally, Rosch and Mervis's family resemblance calculation has been criticized because it unduly inflates the family resemblance score for attributes credited to only one or two members.

For these reasons, Saunders et al. (1991) explored alternative methods to calculate family resemblance scores in order to evaluate their validity. Their study compared five alternative methods. All measures followed Rosch and Mervis's (1975) methodology with some variations. The first measure replicated Rosch and Mervis. A second measure removed attributes credited to only one or two items from the computation of the family resemblance scores. The third measure was calculated using only the attributes mentioned by participants (i.e., no attributes were added by the researchers). The fourth measure included integrated the previous two modifications to the calculation. Finally, the last measure weighed the attributes by the number of participants who mentioned them. The rationale was that the number of participants who identify a given feature should be related to its typicality. Saunders et al.'s results produced positive and significant correlations among all these measures of family resemblance. The present study will calculate family resemblance relying upon the attributes mentioned by participants, and by only crediting features that were mentioned for more than two members of the category.

In summary, an examination of the family resemblance among scientific disciplines will allow me to systematically explore membership status and relationships among disciplines according to people's perceptions. Additionally, it will expose the internal structure of the category *science*. Thus, it will be possible to establish the characteristic features attributed to different academic disciplines, as well as the ones attributed to science. Finally, it will allow me to determine whether psychology is in fact an atypical member of the category *science*. Such inquiry can provide a basis for understanding why people are biased to perceive psychology as unscientific.

Goals

The goal of the current thesis is to determine whether the skepticism towards psychology's scientific status is rooted in the way people process categorical information. To achieve this goal,

I first will explore the content of the semantic domain that underlies people's knowledge of scientific disciplines. A semantic domain is comprised of mental models, whereby given terminology prompts concepts within them (Raaijmakers & Shiffrin, 1981). Free listing is a proven technique to explore semantic domains (Brewer, Garrett, & Rinaldi, 2002) and I hypothesize that psychology is an atypical member of the category *science*. Considering that typical members are named more rapidly and with greater ease in a free listing task (Rosch, 1975), I predict that psychology will be mentioned less frequently, be mentioned later than other more typical sciences, or not be present in the resulting list of members of the category *science*.

Secondly, by investigating typicality using a family resemblance approach, people's conceptual representation of science and psychology can be better understood. According to the prototype theory of concepts (Rosch & Mervis, 1975; Smith & Minda, 1998), the prototypical members are the most outstanding members of a category (i.e., the instances with the highest family resemblance scores). Instances that are not close to the prototype are considered atypical members in that category (i.e., they possess a lower family resemblance score). As mentioned before, I hypothesize that the public will perceive psychology as an atypical member of the category *science*. Thus, I expect that psychology will display a low family resemblance score and that it will have different characteristics from those attributed to the more typical sciences. Hence, I propose that the elements involved in categorization behavior are playing an influential role in biasing people perception of psychology as unscientific.

The present study will also examine the feature "perceived degree of difficulty" attributed to the disciplines. As mentioned previously, significant differences in the perceived degree of difficulty seems to influence people's judgments of what is scientific. Thus, I expected that perceived difficulty would be one of the main features attributed to the category *science*. Hence,

ratings of difficulty should be correlated with family resemblance scores. I also expected that people would perceive psychology as an “easier” discipline than the more typical sciences.

Experiment 1

The main goal of Experiment 1 will be to explore the content of the semantic domain composed of scientific disciplines. Accordingly, it will begin with a free listing task. Participants will be asked to list as many category members as they can think of when the superordinate category *science* is presented. The results will provide a list of disciplines perceived as scientific as well as two measures of typicality of the disciplines (Rosch, 1975).

The second goal of Experiment 1 will be to understand the role of the feature “perceived difficulty” in the typicality of the sciences and the representation of psychology. Accordingly, participants will be asked to rate the difficulty of the academic disciplines. The results from this rating task will provide a measure of perceived difficulty that will be analyzed along with different measures of typicality of the disciplines. Finally, a scientific literacy test (adapted from Impey, Buxner, Antonellis, Johnson, & King, 2011) will be conducted after the main task in order to evaluate participants’ general knowledge of science.

Method

Participants

One hundred and seventy-one participants were recruited for the experiment. The majority of participants were recruited through the Carleton SONA system ($N = 151$). Those participants were enrolled in a first- or second- year psychology course at the time of participation. They were awarded .25% towards their final course grades for their completion of the experiment. Additional participants were recruited online using the Social Psychology Network SPN ($N = 20$). The SPN

is a specialized website that allows researchers to recruit participants to take part in online experiments in the area of social psychology and personality. Participants were invited to participate in the experiment via a short advertisement given on the SPN portal. SPN were volunteers and thus received no compensation for their participation.

Procedure

The free listing task. To obtain the set of academic disciplines that are considered to be scientific according to people's perceptions, participants were asked to name as many scientific disciplines as they could. An adaptation of Saunders et al.'s (1991) instructions was used. The instructions read as follows:

In the first part of this experiment you will be asked to list as many scientific disciplines that come to mind. In order to respond, you will need to first click on the response field and then type your response. There will be 20 blank spaces, please fill in as many as you can. You can take as much time as you need. Once you are ready to move on to the next trial, you will need to click the continue button (>>) at the bottom right hand corner of the screen. You will not have a chance to return and change your answer.

Participants were given numbered fields where they were able to type in their responses. The task was self-paced.

The rating scale task. To obtain an assessment of the extent to which different academic disciplines were perceived to be difficult, participants were asked to provide judgments using a difficulty Likert scale. The academic disciplines of interest included psychology, neuroscience, biology, chemistry, and physics. The remaining cue words were selected to represent a variety of common university disciplines and included agriculture, anthropology, archaeology, astronomy,

business, computers, economics, engineering, geography, history, law, linguistics, mathematics, medicine, philosophy, and sociology.

The difficulty rating task unfolded as follows. Each academic discipline was randomly selected and presented to participants one at a time. Each discipline was embedded in the following sentence: “How difficult to understand do you think _____ is?” Participants were asked to answer on a 7-point Likert scale: 1 will indicate very easy to understand and 7 will indicate very hard to understand. The task was self-paced and ended when all the stimulus word had been presented. The instructions used read as follows:

Next you will be presented with 20 academic disciplines, one at a time. Please rate how difficult you believe each discipline is to understand.

You will be provided with the following scale to use:

- ☐ Very easy to understand
- ☐ Mostly easy to understand
- ☐ Somewhat easy to understand
- ☐ Neither easy or difficult to understand
- ☐ Somewhat difficult to understand
- ☐ Mostly difficult to understand
- ☐ Very difficult to understand

For each discipline, select in the left margin the box corresponding to the degree of difficulty of the discipline. Note, there is no right or wrong answer. All that is important is that you indicate your personal thoughts.

Once you are ready to move on to the next trial, you will need to click the continue button (>>) at the bottom right hand corner of the screen. You will not have a chance to return and change your answer.

The scientific literacy test. To obtain a measure of participants' general knowledge of science, a scientific literacy test (adapted from Impey et al., 2011) was conducted. Participants were asked to answer a series of questions about their knowledge and opinions concerning scientific topics and methodologies. The full scientific literacy test is shown in Appendix D. The task was self-paced.

General procedure

Both participants who were recruited via SONA or the SPN first saw a full description of the experiment, which served simultaneously as the informed consent form. Participants who provided consent were then given a URL directing them to the experiment. All testing took place online via Qualtrics (Qualtrics, Provo, UT). Qualtrics is web-based and it was used to present the experimental instructions, administer the measures, and collect the data. The first task that participants completed was the free listing task. Then, participants completed a rating scale task, followed by scientific literacy test. Finally, the following demographic information was collected: gender, age, country of residence, education level, scientific training level, and fluency in English. In total, the experiment took approximately 30 minutes to complete.

Results

The analyses will be focused on three main research objectives: to explore the semantic domain consisting of disciplines perceived as scientific by the participants, to provide two measures of psychology's typicality (production rank and salience), and to understand the role of

the variable “perceived difficulty” in the typicality of the sciences and the representation of psychology.

Free listing task

The purpose of the free listing task was to explore the structure of a semantic network composed of scientific disciplines. Free listing tasks are often used to explore semantics domains (Brewer et al., 2002). Additionally, according to Rosch (1975), the probability of output and order of mention of items in a free listing task correlates with typicality measures of the items. Therefore, the results from the present task will determine the disciplines that are considered to be scientific and they will assess their typicality.

Demographics

One hundred and thirty-nine participants (81%) reported their country of residence as Canada, ten participants (6%) did not disclose this information, while the rest reported the following countries: United States (7%), Saudi Arabia (2%), Vietnam (1%), China (1%), UK (less than 1%), Croatia (less than 1%) and Libya (less than 1%). The majority of participants self-reported that their scientific training was at a “beginner” level (44%). Otherwise, 40% reported an “intermediate” level, 2% reported an “advanced” level, 11% reported “none”, and 11% of participants did not disclose this information. On average, 73% participants rated their fluency in English as “excellent”, whereas 12% reported “very good”, 7% reported “good”, and 2% “fair” (6% of participants did not disclose this information).

Data screening

In total, the participants generated 2214 responses when asked to list scientific disciplines. Two hundred and eighty were unique. Prior to analyzing cue data, the responses were screened. Spelling was corrected for obvious typos (e.g., “psichology” was coded to “psychology”) and

idiosyncratic responses that were evoked by only one participant were eliminated. This procedure led to the removal of 146 idiosyncratic responses. Lastly, subfields were not collapsed (e.g., “organic chemistry” was not coded as chemistry). This decision was made for three main reasons. Firstly, some subfields were mentioned after the field (e.g., cell biology and molecular biology were named after biology). Therefore, if subfields had been excluded, then the frequency and order of mention calculations would have taken into account only each discipline’s first appearance. Secondly, some of the subfields were impossible to collapse into a single field. For instance, “biochemistry” could have been reasonably coded as either biology or chemistry. Lastly, the different fields depicted superordinate, basic-level, and subordinate members of the category science (e.g., health science, medicine, and anatomy). Therefore, it seemed preferable to allow for the largest possible range of reasonable answers because of the open ended nature of the free listing task that was used.

Typicality among sciences

The remaining 134 unique scientific disciplines were assessed to derive two measures of typicality. First, the frequency (i.e., probability of output) was tabulated. This constituted the first measure of typicality (See Saunders et al., 1991). The results for all disciplines listed by at least 10% of participants are shown in left column of Table 1 (the full list appears in Appendix A). On average, each participant listed 9.63 scientific disciplines. The next step of the analysis involved determining a measure of salience for each discipline. It took into account the frequency, the average rank (shown in the middle column of Table 1), and the number of disciplines produced. The detailed description of this calculation is provided in Appendix B (see Smith & Borgatti, 1998). Salience was the second measure of typicality that was considered (see Rosch, 1975) and

it appears in the right column of Table 1. Finally, frequency and salience are also represented graphically in the left and center panels of Figure 1.

The disciplines' frequency clearly shows that chemistry, biology, and physics were by far the most typical sciences. Psychology was the fourth most frequently mentioned discipline. This would suggest that its typicality score placed it close to the natural sciences. Nonetheless, as shown in Figure 1, the cluster containing the more typical sciences (i.e., chemistry, biology, and physics) is far from all the other sciences. That is, there appears to be a sharp drop in typicality beginning with psychology. Thus, interpreting typicality results by examining solely sciences' ranking order may not be advisable. For instance, as shown in Table 1, the frequency score of chemistry (i.e., the most typical discipline) was 86.5%, in contrast psychology frequency score was 54.4%. This shows an important distance between the disciplines that appears close in rank. Therefore, psychology's typicality should be interpreted with caution. Typicality calculated by Salience presented a similar picture. Once more, it was evident that the hard sciences (biology, chemistry, and physics) were the most typical sciences. Moreover, biology is slightly more typical than chemistry because its average rank (i.e., order of mention) was higher ($M = 2.72$ vs. $M = 3.78$). Salience again identified psychology as the fourth most typical discipline, but its distance from the hard sciences was even greater than it was for frequency. Psychology was mentioned by 54% of participants, but mentioned later than the more typical sciences ($M = 7.16$). This indicates that on average across participants, psychology was mentioned after they had listed the following disciplines: biology, chemistry, physics, biochemistry, geology, engineering, astronomy, organic chemistry, and microbiology.

Table 1.

Scientific disciplines mentioned by at least 10% of participants

No.	Discipline	Frequency (%)	Average Rank	Salience
1	Chemistry	86.5	3.78	0.657
2	Biology	81.3	2.72	0.694
3	Physics	76.6	4.60	0.525
4	Psychology	54.4	7.16	0.319
5	Neuroscience	49.1	7.19	0.264
6	Biochemistry	48.0	5.74	0.309
7	Mathematics	34.5	7.46	0.194
8	Sociology	28.7	8.65	0.136
9	Geology	28.1	6.83	0.162
10	Anthropology	26.9	9.20	0.111
11	Computer science	25.1	9.53	0.109
12	Astronomy	24.6	6.93	0.138
13	Engineering	24.6	6.90	0.128
14	Microbiology	24.0	7.10	0.134
15	Physiology	20.5	10.74	0.077
16	Genetics	19.9	8.59	0.102
17	Anatomy	18.1	11.48	0.072
18	Medicine	14.6	9.56	0.059
19	Geography	14.0	9.71	0.070
20	Ecology	12.9	9.64	0.056
21	Organic chemistry	12.9	6.95	0.078
22	Cell biology	12.3	7.43	0.069
23	Pharmacology	11.7	12.00	0.043
24	Immunology	11.7	7.95	0.065
25	Cognitive science	11.1	8.42	0.055
26	Astrophysics	10.5	9.78	0.045

Figure 1. Different typicality measures showing the distance between each discipline mentioned by at least 10% of participants' frequency (left panel), salience (central panel), family resemblance (right panel).

Perceived difficulty

The goal of this part of the experiment was to determine the extent to which the participants thought that different academic disciplines were difficult to understand. One-hundred and sixty-eight participants provided judgments of difficulty for the cue disciplines and the ratings are shown in Table 2. Engineering was judged to be the most difficult discipline ($M = 6.01$), whereas psychology was judged to be somewhat easy to understand ($M = 3.42$).

Next, I examined if perceived difficulty was related to the two typicality measures. A Spearman correlation analysis found no significant correlation between the perceived difficulty and measures of frequency, $r(11) = .05$, $p = .43$ and salience, $r(11) = .07$, $p = .40$. These correlations seem to suggest that perceived difficulty does not play an influential role in people's judgments of science. However, it is important to note that typicality measures account for the salience of an item among other items of the same category. The typicality measures obtained in Experiment 1 were the result of an open ended task, where the subfields were not collapsed (e.g., anatomy and medicine). This methodological decision modified the rank order of the disciplines to some degree, which ultimately affects the typicality measure of the disciplines (especially the ones with subfields). For instance, if the frequency of anatomy were added to the frequency of medicine, the discipline would have become more typical. Arguably, this could explain why no correlations were found between the typicality measures obtained from the free listing task and perceived difficulty. Experiment 2 will provide a typicality measure that is not subject to this problem.

Scientific literacy task

To evaluate the degree of scientific knowledge among participants, a scientific literacy test was administered to participants. Of the 171 participants in the experiment, 163 completed the

scientific literacy test. The average score for scientific knowledge was 73% and 69% for methodology. Both were averaged for a combined scientific literacy score ($M = .71$, $SD = .14$). Therefore, participants generally had a reasonable understanding of science and its methodology.

Table 2.

Perceived difficulty of the disciplines

Discipline	Mean of perceived difficulty ($N = 168$)	Likert-type scale values
Engineering	6.01	Mostly difficult to understand
Medicine	5.90	
Physics	5.72	
Neurology	5.49	
Chemistry	5.42	Somewhat difficult to understand
Mathematics	4.94	
Computers	4.89	
Astronomy	4.61	
Biology	4.61	Neither easy or difficult to understand
Economics	4.52	
Law	4.31	
Linguistics	4.04	
Archaeology	3.99	Somewhat easy to understand
Philosophy	3.86	
Business	3.76	
Anthropology	3.42	
Psychology	3.42	Somewhat easy to understand
Agriculture	3.35	
History	3.32	
Geography	3.13	
Sociology	2.92	Mostly easy to understand

Discussion

The purpose of this experiment was to explore the semantic domain composed of scientific disciplines using a free listing paradigm. Participants were asked to list as many sciences as they could. This yielded a list of disciplines represented as scientific according to people's perceptions. In addition, it provided two indirect measures of science's typicality. I expected that the hard sciences (e.g., biology, chemistry, and physics) would be represented as more typical sciences based on the measures of typicality assessed (i.e., they would be mentioned earlier on participants lists and more frequently). Additionally, I expected that psychology would be perceived as an atypical science. That is, it was expected that psychology was mentioned less frequently and later on participants' lists compared to the more typical sciences, or not be listed at all. The second goal of this experiment was to understand the role of the variable "perceived difficulty" in the representations of the sciences and psychology. To understand the role of "difficulty", participants were asked to judge how difficult they believed 20 academic disciplines were. I expected that "perceived difficulty" would be correlated with typicality measures of the sciences. I also expected that people would perceive psychology as an "easier" discipline compared to the more typical sciences.

As hypothesized, the results suggested that biology, chemistry, and physics were perceived to be the most typical disciplines. Surprisingly, psychology was ranked as a relatively typical discipline according to both measures of saliency. That is, frequency and salience typicality calculations determined that psychology was ranked as the fourth most typical discipline (behind

biology, chemistry, and physics). However, these measures were not correlated with “perceived difficulty”. Nonetheless, the more typical sciences did generally receive higher judgments of difficulty than the less typical sciences. Additionally, psychology was represented as one of the easiest disciplines, as predicted.

Perhaps, the representation of psychology as relatively similar to the more typical sciences, and the unclear results regarding the role of perceived difficulty in the representation of science, may be due to some limitations regarding measuring typicality with a free listing task. Namely, free listing tasks are open ended tasks in which the frequency and order of mention of items offers a significant correlation with items’ typicality (Rosch, 1975). Then, the open nature of the task could influence the typicality assessment. For instance, in the present study sub-disciplines mentioned during the free listing task were not collapsed with basic level disciplines. The latter impacted on the frequency of the disciplines, hence, their typicality scores.

The next experiment will address this issue by using a different typicality measure: family resemblance scores. The family resemblance relationships among sciences will allow me to determine the degree of typicality of the disciplines, which will provide more data regarding psychology’s status among the sciences as well as the role that perceived difficulty plays in this phenomenon. Additionally, it will also allow me to determine which features people use to represent science and psychology. Thus, the internal structure of the category *science* will be examined.

Experiment 2

The goal of Experiment 2 was to examine the internal structure of the category *science* using the family resemblance approach to further explore of psychology's status among the sciences. Consequently, the second experiment consisted of a feature listing task adapted from Rosch and Mervis (1975) was conducted.

Method

Participants

Ninety-two undergraduate psychology students were recruited through Carleton University's SONA system. As in Experiment 1, the inclusion criterion for this study was that all participants had to be enrolled in a first- or second- year psychology course at the time of participation. Participants were awarded .25% towards their final course grades for their completion of the experiment.

Stimuli

The scientific disciplines used in the feature listing task were taken from Experiment 1. This procedure ensured that the features of science obtained in the present experiment were prompted by disciplines that people had categorized as scientific. Twenty-six disciplines were mentioned by at least 10% of participants (see Table 1), but many described subfields (e.g., microbiology, cell biology, organic chemistry, astrophysics, etc.). These disciplines were eliminated due to the fact that exploratory analyses of the internal structure of categories are usually conducted at the basic level of the category (Rosch & Mervis, 1975). Finally, disciplines that contained the word "science" were modified or excluded. Hence, "computer science" was changed to "computers", "neuroscience" was changed to "neurology", and "cognitive science" was excluded. These steps yielded a list of 13 scientific disciplines shown in Table 3.

Table 3.

Disciplines used as stimuli in Experiment 2 (feature listing task).

Item	Discipline
1	Anthropology
2	Astronomy
3	Biology
4	Chemistry
5	Computers
6	Engineering
7	Geography
8	Mathematics
9	Medicine
10	Neurology
11	Psychology
12	Physics
13	Sociology

Note. These disciplines are sorted alphabetically.

Procedure

Participants were asked to list the attributes possessed by each discipline. An adaptation of Rosch and Mervis's (1975) and McRae et al.'s (2005) instructions were used. The instructions read as follows:

This is a very simple experiment to find out what people know about different academic disciplines. On the next screen, you will be presented with the name of an academic discipline followed by blank lines. Please fill in as many of these lines as you can with properties, attributes, and characteristics of the discipline. For example, you could list its topic of study, the equipment that the discipline uses, or concepts that are related to it. Please, try not to free associate! For example, if Geology just happens to remind you of

your father, don't write down father. Below, we have provided examples to give you an idea of what might be considered a property description of a discipline.

Geology

- The study of rock
- How the earth changes over time
- Maps

Zoology

- Evolution
- Study of animals
- Collection and preservation

You may be able to think of more or different types of properties for these disciplines, but these examples should give you an idea of what is requested of you. Please do not spend too much time on any given word, but also please take a bit of time to consider the relevant properties of each cue discipline. In other words, complete this questionnaire reasonably quickly, but keep the relevant types of properties in mind.

When you are ready, press continue button (>>) and read the displayed word, then write down the attributes or characteristics you think are characteristic of the cue discipline as fast as you can until you're presented with the next cue discipline. You will be timed during this experiment. You will have one and a half minutes to list at least ten features for each discipline. Once this time is over, you will automatically be presented with a new discipline. If you do not require the full minute and a half, you can press the continue button (>>) to be presented with a new discipline.

After participants completed the feature listing task, a scientific literacy test (adapted from Impey et al., 2011) was conducted. Participants were asked to answer a series of questions about

their knowledge and opinions concerning scientific topics and methodologies. The full test is shown in Appendix D it was self-paced. The following demographic information was collected after the scientific literacy test: gender, age, country of residence, education level, scientific training level, and fluency in English. All testing took place online via Qualtrics (Qualtrics, Provo, UT). In total, the experiment took approximately 45 minutes to complete.

Results

The purpose of Experiment 2 was to examine the structure of the category *science*. The analyses focused on four research goals: to find the features attributed to science as well as the relationships among scientific disciplines, to test the correlations between the disciplines' family resemblance and typicality, to provide a third measure of psychology's typicality, and to explore the role of the variable "perceived difficulty" in the typicality of the sciences portrayed by the family resemblance scores.

Feature listing task

The purpose of the feature listing task was to investigate people's conceptual representation of science and psychology using a family resemblance approach. The study of family resemblances among academic disciplines will determine the characteristic features attributed to different academic disciplines, as well as the ones attributed to the category *science*. Finally, it will provide a third measure of psychology's typicality in relation to the other sciences.

Demographics

All participants reported their country of residence as Canada, except for one who reported her country of residence as Norway. The majority of participants self-reported that their scientific training was at a "beginner" level (47%), 22% reported an "intermediate" level, and 29% reported

“none”. Two percent of participants did not disclose this information. On average, most participants rated their fluency in English as “excellent” (84%), whereas 14% reported “very good”, 1% reported “good”, and 1% “fair”.

Data screening

Before analyzing cue data, the responses were screened. Spelling was corrected for obvious typos (e.g., “intersting” was changed to “interesting”). Plurals and singulars were collapsed (e.g., “chemical” and “chemicals”) whereby the more frequent term was chosen. Qualifiers (e.g., “the” and “a”) and adjectives (e.g., “very”) were eliminated and the root word was kept (e.g., “the brain” was coded to “brain”, and “very creative” was coded to “creative”). Features joined by “and” were considered to represent two distinct features for the analyses (e.g., “mind and brain” was coded to “mind” and “brain”). Features which were synonyms were collapsed (e.g., “hard” and “difficult”) whereby the more frequent term was chosen. Lastly, the superordinate “science” and some ordinales disciplines were mentioned by participants when they were asked to name features of the disciplines. For instance, the term “science” was evoked by the cue discipline “chemistry”, and “chemistry” was evoked by “biology”. A methodological decision to exclude these words as features was made, because the category name or other items in the category do not necessarily constitute features of a discipline. These data will be analyzed in a later section, however. Two judges performed the screening separately. Next, they reviewed the resulting table and indicated cases in which they recoded an attribute differently. Discrepancies between judges were infrequent. Per discipline, there were approximately 280 words and approximately 14 discrepancies in coding between judges. Thus, overall, judges had to consult on 5% of coding disagreements per discipline. Agreement was reached in approximately 95% of the problematic cases. The remaining 5% of words where agreement was not reached were left uncoded. This

decision did not influence the final results because infrequent responses were excluded from analyses (i.e., the family resemblance calculations only considered features mentioned by at least 10% of participants).

Family resemblance

Once the screening process was completed, a list of 1154 features was obtained. Anthropac v. 4.92 (Borgatti, 1996) was used to identify the number of times each property was listed for each discipline. All properties listed for any discipline by at least 10% of participants were incorporated into the analysis. Following Malt and Smith (1984), this criterion was used in order to exclude features that were so low in salience that most participants did not think of them. In total, 156 features were mentioned for the 13 cue disciplines by at least 10% of participants (for lists including all the features mentioned for each discipline, see Appendix C). The properties that met the criterion included many properties which, although highly salient for one discipline, were not mentioned for any other (e.g., "programming" was listed by many participants for computers). Next, the overlapping features among the disciplines were identified. For a meaningful overlap among features to exist, the present study only considered features attributed to more than two members (following Saunders et al., 1991). Finally, each feature was credited with the number of disciplines for which a given feature was mentioned. For example, "intelligence" was mentioned for computers, engineering, and physics, and thus it was granted a weight of 3. The final calculation of family resemblance considered the sum of all the weighted attributes granted to each discipline. Table 4 shows each feature with its overlapping frequency among the disciplines. The results indicated that the features attributed to the category *science* were difficult, people, experiment, chemicals, formulas/equations, development, and behavior.

Table 4.

Main features attributed to “Science” and its overlapping frequency.

Feature	No. of scientific disciplines that presented the feature	Freq. (%)
Difficult	7	53.8
Humans	5	38.5
Experiment	4	30.8
Chemicals	4	30.8
Formulas/equations	4	30.8
Development	3	23.1
Intelligence	3	23.1
Behavior	3	23.1

In terms of category structure, Table 5 shows the distribution for the number of attributes applied to each discipline. Table 6 shows the family resemblance relationship among scientific disciplines. The highest family resemblance scores were obtained for chemistry and neurology (FR score = 19), closely followed in rank by physics and engineering (FR score = 18). In contrast, the lowest family resemblance scores were obtained for astronomy and geography (FR score = 0). This score indicates that none of the main features of science were attributed to these disciplines.

One of the hypotheses of the experiment was that the family resemblance structure would prove to be significantly correlated with the prototypicality of the disciplines. Spearman rank-order correlations were computed for the two measures of typicality obtained in Experiment 1 and their measure of family resemblance. A significant correlation between family resemblance and frequency, $r(11) = .54, p = .03$, as well as a trend for the correlation between family resemblance and salience, $r(11) = .45, p = .06$, were found. These results confirm Rosch and Mervis's (1975) findings that the more an item has attributes in common with other members of the category, the more it will be considered a “good” and “representative” member of the category. The right panel of Figure 1 shows the distance among the disciplines according to the third measure of typicality

of the present research (i.e., typicality according to family resemblances scores). It suggests that people perceive chemistry, neurology, physics, and engineering as the most prototypical members of the category *science*. In contrast, people perceive astronomy and geography to be the least typical or “worst” examples of science. The results from this experiment also showed that difficulty was the main feature attributed to science.

Table 5.

Number of attributes in common among members of the category “Science”

Science	No. of shared attributes
Chemistry	4
Neurology	4
Engineering	4
Physics	4
Psychology	4
Mathematics	2
Medicine	2
Sociology	3
Computers	2
Biology	2
Anthropology	2
Astronomy	0
Geography	0

It is important to note that science is a broad category. Disciplines show great variety across topics of study, instruments used, and methodological practices. Among the main features of science found by the present research, there appears to be a distinction between features mostly shared by the more typical sciences and another set of features mostly shared by the less typical sciences. Figure 2 clearly shows that the four most typical sciences found in the present research mainly shared the features difficult, experiment, chemicals, equations/formulas and intelligence,

whereas the other main overlapping features of science (i.e., people, development and behavior) were shared mostly by the less prototypical sciences (i.e., anthropology and sociology). There were only three cases where the disciplines elicited both sets of features: biology, psychology, and neurology. For instance, biology was given two of the main overlapping features: one feature from the more typical disciplines (i.e., experiment) and one for the less typical disciplines (i.e., people). Psychology was credited mostly with features shared by the less prototypical disciplines (i.e., people, development, and behavior) and shared only one feature with the more typical disciplines (i.e., experiment). The case of neurology is interesting because as part of the more prototypical sciences, it shared two of the features elicited for the more typical disciplines, and at the same time was also given two of the features shared by the less prototypical disciplines (e.g., people and behavior).

Figure 2. Main features of science attributed to each discipline. Features in red were shared mostly by the more typical sciences. Whereas, features in blue were mostly shared by the less typical sciences.

Table 6.

Family resemblance among scientific disciplines

Main features of science	Difficult	Experiment	Chemicals	Equation/Formula	Intelligence	People	Development	Behavior	FR scores
Chemistry	7	4	4	4					19
Neurology	7		4			5		3	19
Physics	7	4		4	3				18
Engineering	7		4	4	3				18
Psychology		4				5	3	3	15
Mathematics	7			4					11
Medicine	7		4						11
Sociology						5	3	3	11
Computers	7				3				10
Biology		4				5			9
Anthropology						5	3		8
Geography									0
Astronomy									0

Note. Disciplines credited with a feature show a number that indicates its weight (i.e., the number of disciplines for which the feature was mentioned). The final FR score is the sum of all the weighed features attributed to each discipline.

Perceived difficulty

An additional analysis explored the role played by the variable “perceived difficulty” in the representation of “science”. It found significant correlation between the Family Resemblance scores and judgments of Difficulty provided by participants in Experiment 1, $r(11) = .61$, $p = .01$. This finding suggests that the measure of how difficult a discipline is represented is correlated with people’s judgments of how good of an example it is of science. Moreover, the representation of science as being “difficult”, as depicted by participants in Experiment 2, provides additional support for this finding. Across all disciplines, the feature “difficult” was evoked so frequently that it was the most characteristic feature of science. Table 7 shows the percentage of participant that evoked the feature “difficult” for each discipline (percentages lower than 10% included).

Table 7.

Frequency of the term Difficult evoked in the feature listing task.

Science	Frequency (%)
Mathematics	37.20
Physics	34.20
Engineering	27.50
Computers	15.40
Neurology	15.00
Medicine	13.00
Chemistry	10.20
Biology	7.30
Psychology	2.40
Anthropology	2.30
Astronomy	2.20
Geography	0.00
Sociology	0.00

A significant correlation was found between the measure of evoked “difficulty” obtained from Experiment 2 and the judgments of academic difficulty obtained from Experiment 1, $r(11) = .81, p < .001$. Furthermore, evoked “difficulty” was also significantly correlated with the Family Resemblance scores, $r(11) = .55, p = .02$. Thus, the more typical sciences were also depicted as the most difficult. Psychology was represented as being an “easy” discipline rather than a “difficult” one using both direct (i.e., ratings of difficulty from Experiment 1) and indirect measure (i.e., evoked difficulty in Experiment 2).

Evoked importance

Previous research has suggested that “difficulty” is an important a feature of science (Keil et al., 2010). This hypothesis was evaluated in the present research by using both a direct measure (i.e., rating of difficulty) and an indirect measure (i.e., evoked difficulty). Previous research has also suggested that “importance” is a feature attributed to science (Krull & Silvera, 2013). Although, a discipline’s level of judged “importance” was not directly assessed in the present research, an indirect measure of disciplines level of “importance” was obtained from Experiment 2. Table 8 shows the percentage of participant that listed “important” as a feature for each discipline (percentages lower that 10% included).

As can be seen in Table 8, few participants listed “importance” as a feature. For that reason, “importance” was not found to be one of the main overlapping features of science. In fact, no correlation was found between evoked “importance” and Family Resemblance scores, $r(11) = .16, p = .30$. However, a significant correlation between evoked “importance” and evoked “difficulty”, $r(11) = .48, p = .05$ suggests that as a discipline is judged to be more difficult, it is also judged to be more important. This finding was corroborated with the more direct measure of difficulty. More specifically, a significant correlation was also found between Evoked Importance and Ratings of Difficulty, $r(11) = .48, p = .05$. The present study found that psychology was represented as one of the least important sciences.

Table 8.

Frequency of the term Important evoked for each discipline in the feature listing task.

Science	Frequency (%)
Computers	7.70
Engineering	7.50
Medicine	6.50
Biology	4.90
Mathematics	4.70
Chemistry	4.10
Neurology	2.50
Sociology	2.40
Geography	2.40
Physics	0.00
Psychology	0.00
Anthropology	0.00
Astronomy	0.00

The conceptual representation of psychology

The present research hypothesized that psychology would be an atypical science based on its family resemblance with other scientific disciplines. The results showed that psychology was actually ranked closer to the more typical disciplines than the atypical ones. Nonetheless, the features that were elicited for psychology were all associated with the less typical sciences except for the feature “experiment”. This suggests that people’s mental representation of psychology is not to the same as those of the most typical sciences. Further exploration of the semantic associates and the distribution of the semantic space among category members can provide more information regarding the representation of the category *science* and psychology.

Analysis of the semantic associates

A noteworthy finding of the feature listing task is that the superordinate “science” and some subordinate disciplines were produced by participants when they were asked to name features of the disciplines (e.g., “chemistry” was evoked by the cue discipline “engineering”). These responses were excluded from the family resemblance calculations. However, these semantic associates may also provide a portrait of the representation of science in people’s minds. More specifically, they may yield information about the relationships among words learned as a result of experience.

According to the lists of features mentioned by at least 10% of participants (see Appendix C), the superordinate *science* was evoked by participants when they were asked to name features of chemistry (49%), physics (42%), biology (39%), engineering (35%), computers (15%), medicine (15%), and astronomy (11%). This measure shows how strongly each discipline is semantically associated with science. It is important to note that “social science” was evoked for the cue psychology (12%) and sociology (12%).

Additionally, some disciplines were evoked as features of other disciplines (e.g., physics was evoked by engineering) (see Appendix C). Interestingly, only four disciplines were evoked by more than one member of the category *science*. These disciplines are chemistry, physics, biology, and mathematics. Hence, this finding indicates that these disciplines were more common associates among members of the category *science*. This finding seems plausible when considering that the main features of science are chemicals, formulas, and equations.

Analysis of the semantic space

Investigating the semantic space in which the items of any category are embedded represents another way of visualizing and exposing otherwise hidden structures in data. Similarity

judgments of the members can be used to assign a coordinate to each member, and then, multidimensional scaling (MDS) plots them into a semantic map where the coordinates on the map represent their positioning in the common space. According to Smith, Shoben, and Rips (1974), items perceived as closest to all items of a group of items fall in the center of the space defined by proximity scaling of those items. Therefore, Rosch and Mervis (1975) argued that the members with the greatest family resemblance scores would fall in the center of the semantic space defined by proximity scaling of similarity judgments between all pairs of members of the category. Accordingly, items should be perceived as similar to each other due to the attributes (identified by the family resemblance methodology) which they have in common. That is why they also argued that the distance of each member from the origin of the space should be determined by their degree of family resemblance.

To examine these ideas in the context of the present research, a multidimensional scaling analysis was performed on a data set that was originally presented in Plagianakos (2016). This study collected similarity judgments of 26 academic disciplines. The MDS used only the subset of disciplines that were listed as sciences according to participants' responses in Experiment 1 (see Table 3). Then, the averages of the coordinates obtained from the scaling solution were calculated and used as a measure of the distance from the center of each member (following Rosch & Mervis, 1975). Finally, the distance of each discipline from the center of the common space was correlated with family resemblance scores obtained by the Experiment 2 of the present research.

In sum, the MDS analysis was conducted with similarity judgments of all possible pairs of 13 scientific disciplines provided for 143 undergraduate psychology students. The scree plot indicated that two dimensions were a good fit of the model (see Figure 3). As indicated by the elbow in the scree plot, the first and second dimension accounted for most amount of the stress in

the model (approximately 89%). The addition of a third or fourth dimension did not contribute to a great amount of improvement of the model (only about 4%). The stress value of the two-dimensional solution was .12, which is “good/fair” according to Kruskal’s stress test.

Figure 3. Scree plot showing stress levels of the model.

The results showed that the most prototypical sciences appeared to be the most central in the scaling solution. Figure 4 shows the semantic space in a two-dimensional scale. It is evident that the less typical disciplines were further away from the center as Rosch and Mervis (1975) suggested. They had also found a significant correlation between the distance of the items from the origin of the semantic space and the family resemblance scores. This finding was successfully

replicated in the present study. A Spearman's rank-order correlation was conducted to determine the relationship between the degree of family resemblance as measured in the present experiment and the distance of an item from the origin in a two-dimensional scaling solution. It was significant, $r(11) = -.54, p = .03..$ Hence, a larger distance from the center accounted for a lower family resemblance score. This is particularly evident in the case of astronomy and geography. Both are clearly located far from the center of the scaling solution and both generated the lowest family resemblance scores.

Figure 4. A two-dimensional solution of the same different judgments of the 13 cue disciplines.

In summary, the main overlapping features determined by the present research were significantly correlated with similarity judgments of the disciplines taken from a different sample of subjects. The latter provides confidence in the features of science and typicality scores found

by the present research. It is important to note that if typicality predicts centrality in a semantic space, then the unique coordinates representing psychology in the scaling solution provides support for the idea that psychology is represented as an atypical member of the category *science*. This can be found upon examining Psychology's position in Figure 4. It is clearly far from the center. Also far from the center we can find astronomy, geography, sociology, and anthropology (disciplines found to be the less prototypical by the present study). Finally, regarding the representation of science, this analysis portrays a similar picture to others results of the present study (i.e., the representation of chemistry, physics, and biology as very typical sciences).

Scientific literacy task

Of the 92 participants, 88 completed the scientific literacy test. The average score for scientific knowledge was 72% and it was 75% for methodology. Both were averaged for a combined scientific literacy score ($M = .74$, $SD = .13$). Therefore, participants generally had a reasonable understanding of science and its methodology.

Discussion

The main goal of this experiment was to explore the internal structure of the category *science* using the feature listing paradigm. Participants were asked to list the attributes possessed by each discipline. This methodology provided the representative features of science as well as another typicality measure of the sciences. Based in the results from Experiment 1, it was expected that psychology's family resemblance score would place it relatively close to the more typical sciences. In other words, that psychology was represented in a similar way (with similar features to) the more typical sciences.

The results of this experiment indicated that the features attributed to the category *science* were difficult, people, experiment, chemicals, formulas/equations, development, and behavior.

Additionally, “difficult” was represented as the most characteristic feature of science. Moreover, the family resemblance results suggest that people perceived chemistry, neurology, physics, and engineering as the most prototypical members of the category *science*. As found in Experiment 1, psychology was not represented as one of the “best” examples of science. Nonetheless, its family resemblance score placed it relatively close to the more typical sciences. That is, psychology did in fact possess many of the features of science.

It is important to note that the category *science* is broad and the features found by the present research revealed two distinct set of features that represent science in people’s minds. Interestingly, one set of features was shared mostly by the most prototypical sciences, whereas the other set of features was shared mostly by the least prototypical sciences. More specifically, the four most typical sciences shared the features difficult, experiment, chemicals, equations/formulas, and intelligence. In contrast, features of the least prototypical sciences included people, development, and behavior. Psychology did not share many features with the most prototypical sciences. Rather, its features were those that were shared by the least prototypical sciences. Thus, psychology’s high typicality score was mostly due to features shared with the less prototypical disciplines (i.e., people, development, and behavior) and it shared only one feature with the more typical disciplines (i.e., experiment).

In sum, the family resemblance scores place psychology relatively close to the best examples of science. This would suggest that psychology is similar to the more typical sciences. However, the internal structure of the category *science* portrays a different picture. Specifically, it shows a distinctive set of features attributed to the best examples of science. These distinctive features are almost completely absent from psychology’s conceptual representation. Hence, psychology’s typicality should be interpreted with caution. Actually, if the set of features are taken

into account, psychology seems more similar to the less typical sciences found in the present research (i.e., sociology and anthropology). Therefore, besides the relatively high family resemblance score that psychology holds, a closer examination of the results from the present experiment suggests that in fact psychology is not a typical scientific discipline.

General discussion

In the present study, I investigated how participants' categorization behavior may be influencing the perception that psychology is unscientific. In Experiment 1, chemistry, physics, and biology were found to be the most typical scientific disciplines. Although psychology was mentioned less frequently and later than the most typical sciences, it was found to be the fourth most typical science using two different typicality measures. Thus, psychology's typicality scores placed it relatively close to the most typical disciplines. In Experiment 2, chemistry, physics, engineering, and neurology were found to be the most typical sciences based on family resemblance scores. The features that represented these more typical sciences were difficult, experiment, intelligence, equations/formulas, and chemicals. As in Experiment 1, psychology was relatively close to the more typical disciplines. However, an analysis of the internal structure of the category *science* showed that psychology was not represented in a same way as the most typical sciences. Mainly, psychology shared few features with the more typical sciences and many features with the atypical ones. Additionally, the disciplines that were judged to be more typical sciences were perceived to be more difficult. They were also perceived to be more important. Psychology was judged to be neither difficult nor important. Once again, this suggests that psychology is not represented in the same way as the most typical sciences. Finally, an analysis of the semantic domain of scientific disciplines found that psychology was not semantically associated to science.

Instead, chemistry, physics, biology, engineering, computers, medicine, and astronomy were associated to science. Moreover, psychology was located further away from the center in a semantic space composed of scientific disciplines, in which centrality predicted typicality. In the next four sections, these findings will be discussed in detail.

Psychology as an easy discipline

The present research found that that “difficult” was one of the most characteristic features of science. The role of “difficulty” was assessed using a direct measure (i.e., ratings of difficulty) and an indirect measure (i.e., evoked difficulty). Both measures were significantly correlated with the typicality of the disciplines according to the family resemblance scores. Therefore, the degree to which a discipline is considered to be “difficult” was related to people’s judgments of how good an example of science it was. As hypothesized, psychology was not represented as being a “difficult” discipline. In fact, psychology was actually judged to be “somewhat easy” to understand.

These results are reminiscent of those presented by Keil et al. (2010) who found that children judged natural science phenomena to be more difficult than psychological ones. Keil et al. argued that children were more confident about these latter judgments because of their access to their own psychological states. The results of the present experiments suggest an alternative explanation. In the present research, the more typical sciences (i.e., the natural sciences) were found to be strongly associated with the feature “difficult”. Hence, the children may have been using a simple heuristic instead of actually assessing Keil et al.’s questions: if a question elicits mental representations associated with a typical natural science, then it is difficult. Otherwise, it is not.

Psychology as an unimportant discipline

Previous research has found that disciplines that were judged to be less scientific were also judged to be less important (Krull & Silvera, 2013). This hypothesis was not directly assessed in the present research. However, the feature listing task provided an indirect measure of the importance attributed to the scientific disciplines. Specifically, importance was evoked as a feature for some scientific disciplines. The correlation between evoked importance and family resemblance scores was not significant. Nonetheless, there was a trend among the more typical disciplines to be represented as more important than the less typical disciplines. Psychology was represented as one of the least important sciences. This finding supports the idea that psychology is not perceived in the same way as the more typical sciences. Therefore, it is possible that the belief that psychology is not important leads to the belief that it is unscientific. This provides further support for the idea of that the mechanism underlying people's skepticism of psychology's scientific status is rooted in the categorization process.

The relationship between perceived importance and the degree to which a discipline is viewed as scientific has been explored in other research. For instance, Hartwig and Delin (2003) found that psychology was judged to be one of the "least important or needed" disciplines. Similarly, Janda et al. (1998) found that psychology's and sociology's contributions to society were rated to be significantly less important than those of biology, chemistry, physics, and medicine. The present study suggests that these results could also be explained by the cognitive mechanism underlying categorization. That is, the more typical sciences (i.e., the natural sciences) were found to be associated with the feature "important". Thus, once again participants may have been using a simple heuristic instead of actually assessing psychology's contributions to society. More specifically, natural sciences may be stereotypically more strongly associated with important

findings, and less typical sciences may lack this association. The present research found that the conceptual representation of psychology is very similar to the conceptual representation of the less typical sciences (i.e., anthropology and sociology). This may be why it lacked an association with the feature “important”.

Semantic associates of science

Further support for the hypothesis that psychology is not perceived in a similar way to the more typical sciences was provided by an analysis of the semantic associates of science. According to Raaijmakers and Shiffrin (1981), a semantic associative network is composed of terms that represent the imagery and concepts within the network. The present study found that chemistry, physics, biology, engineering, computers, medicine, and astronomy were terms associated with the term *science*. Psychology instead was associated to the term *social science*. The same phenomenon was observed in the case of sociology.

Previous research also found that psychology is not a strong semantic associate of science. In her study concerning the representation of psychology as unscientific, Morgan (2015) used a discrete free association task to systematically examine people’s perception of psychology. The results showed that the term psychology did not elicit the associate *science*, whereas many other academic disciplines did. However, she did find some common associates between science and psychology. More specifically, both shared the features research, study, and experiment. She argued that people may represent science by its object of study rather than its methodology. Similarly, Krull and Silvera (2013) argued that superficial features rather than the use of the scientific method may drive judgments about science. The results found in the current study can provide empirical support for these explanations. Mainly, the present research found that indeed, the representation of science is mainly constituted of superficial features, such as difficult, people,

chemicals, intelligence, and behavior. Actually, features depicting the scientific method were almost absent from the internal structure of the category *science*. The representation of science only included one feature that considered the scientific method, namely experiment. Other related features such as observation, theory, or research were mentioned infrequently by participants. Therefore, the present research provides evidence that the conceptual representation used by people to make judgments about science has little to do with the use of the scientific method.

Semantic space among scientific disciplines

More evidence suggesting that psychology is not a typical scientific discipline can be found by exploring a semantic space composed of the sciences. A semantic map represents the psychological distance among terms of a semantic network. Smith et al. (1974) established that items perceived as more similar to a group of items fall in the center of the space defined by proximity scaling of those items. Later, Rosch and Mervis (1975) found that the members with the greatest family resemblance scores fell in the center of the semantic space defined by proximity scaling of similarity judgments between all pairs of members of the category. Thus, the property of centrality in the common space of members of any category predicts typicality. The present study presented a scaling solution using similarity judgments between all pairs of the same scientific disciplines used in the feature listing task. The present research successfully replicated Rosch and Mervis (1975). The family resemblance scores were significantly correlated with the distance from the center of the disciplines. Moreover, as Rosch and Mervis predicted, the two-dimension scaling solution clearly showed that the most typical members were located closer to the center. Psychology was located further away from the center than the most typical disciplines. Therefore, the semantic space of scientific disciplines provides more evidence of the representation of psychology as not a very typical science. Once again, the latter suggests that the categorization

process would constitute the cognitive process behind the representation of psychology as unscientific.

Psychology as the best example of the social sciences

The current study found that psychology is categorized differently than the more typical sciences. As a result, it was not found to be a good example of science. This may seem disputable given the fact that psychology had a relatively high scientific typicality. However, the conflict between psychology's high typicality measure and its singular set of features may be explained by the nature of the category *science*. Science is multifaceted and scientific disciplines are diverse. This fact was captured by the results from the feature listing task whereby attributes that represented science were listed. The results clearly showed that participants distinguished between two kinds of sciences: the natural and the social. Psychology possessed a high family resemblance score because it was represented with all the main features attributed to the social sciences and one feature from the natural sciences. Therefore, a careful examination of the internal structure of the category *science* suggests that while chemistry is perceived as the "best" example of the natural sciences, psychology is perceived as the "best" example of the social sciences. These observations reconcile psychology's high typicality scores with the fact that psychology does not seem to be strongly associated with science in people's minds.

Explaining the cognitive mechanism underlying the "allure" of neuroscience information

The results of the current study provided empirical evidence showing that categorization behavior may be the cognitive mechanism behind previous research findings regarding the so-called "allure" of neuroscience information. For instance, Weisberg et al. (2008) found that irrelevant neuroscientific information influences people's judgments about scientific reasoning.

Specifically, explanations of psychological phenomena with irrelevant neuroscience information are judged to be more satisfying than explanations without neuroscience information. Weisberg et al. (2015) replicated these findings under different conditions and claimed that they fit a “prestige of science” explanation. They argued that people are generally skeptical about psychology because they think that its methods are not the same as those of “real science”. In contrast, the natural sciences are seen as generally more credible and reliable sources of scientific knowledge. Thus, because neuroscience is more typical of the natural sciences, then it is regarded as a more prestigious science. Unfortunately, Weisberg et al. (2015) did not provide any direct empirical evidence in support of this claim, but the results of the present experiments do. Specifically, the natural sciences were found to be the most typical members of the category *science*, neuroscience was found to be one of these more typical sciences, and psychology was not represented in the same way as these more typical sciences.

In sum, the results from the present research provide empirical support for the hypothesis that the categorization process is the cognitive mechanism behind the influence of superficial details like neuroscience jargon on scientific reasoning. This is particularly true considering that stereotypical representations of science and not actual knowledge of the scientific method or deeper understanding of scientific reasoning are responsible for people’s judgments of science. Lastly, I would argue that the allure of neuroscience is a consequence of a combination of three phenomena: judgments about science are based on stereotypes of science, neuroscience is represented as one of the best examples of science, and generally, studies compare a preference for neuroscience information to a preference of psychological information. Thus, the allure may simply reflect the gap in typicality between psychology and neuroscience.

Limitations

The present study used the family resemblance approach to systematically explore whether categorization behavior was the cognitive mechanisms underlying the perception of psychology as unscientific. While the selected methodologies successfully examined psychology's conceptual representation and its relationship to the sciences, it should be acknowledged that some methodological limitations were present. For instance, in Experiment 1, a free listing task was used to explore the content and scope of the semantic domain of the sciences according to people's perceptions. Additionally, this task yielded two measures of typicality. According to Rosch (1975), free listing tasks are open ended tasks where the frequency and order of mention of items offers a significant correlation with items' typicality. Therefore, the open nature of the task could influence the typicality assessment. For instance, the fact that sub-disciplines were not collapsed with the basic level disciplines could have had an impact on the assessment of typicality.

To eliminate some of the shortcomings of a free listing task, a feature listing task was employed in Experiment 2. Besides providing a new typicality measure, this task also successfully explored the conceptual representation of science and psychology according to people's perceptions. However, one possible limitation of the selected methodology could be that the present study did not find "importance" as one of the main features of science. As discussed in previous sections, the data seem to indicate that "importance" is in fact one of the main features of science. Then, the reason behind the low frequency of the feature "importance" among the scientific disciplines, and the consequent lack of overlap within the sciences could be due to a methodological limitation, specifically, a coding issue. Some features were relatively straightforward to code (e.g., difficult, hard, hard work, hard to wrap the head around, hard to grasp, were all coded as difficult). Importance, on the other hand, was more difficult to code, because some

responses (e.g., necessary, useful, helpful, helping people) seemed to indirectly refer to importance. However, these responses were not recoded due to disagreement between the judges during the coding process. Future research should consider exploring how strongly associated these features are to certain disciplines. For example, an Implicit Association Test (Greenwald, McGhee & Schwartz, 1998) could be employed to assess the associative strength between the main features attributed to science found by the present research and the scientific disciplines. Then, the feature “importance” could be added to the analysis to assess if in fact is one of the main features used by people to characterized the sciences.

In sum, the free listing and feature listing tasks were chosen for the present research to assess typicality among the sciences, in addition to the semantic domain and the internal structure of the category *science*. To eliminate possible shortcomings of the listing tasks to assess typicality, future researchers who are exclusively interested in the typicality assessment could use different methodologies. For example, an Implicit Association Test could be employed to assess the associative strength between science and several scientific disciplines. In this case, it would be predicted that participants would respond quicker when the category name and the most typical disciplines are displayed together. A different task could involve asking participants to judge how good an example of science various disciplines are. Typicality ratings could be collected on Likert scales.

Finally, the surprisingly finding of psychology’s typicality as closer to the natural sciences could be also explained by another methodological limitation. Even though psychology’s distance from the most typical disciplines was significant, on average it was still closer to the main cluster than any other discipline. Arguably, this phenomenon could be in part the result of the sample

given that the majority of participants were undergraduate psychology students. Thus, it is possible that the participants may have been particularly inclined to identify their major as a science. This seems especially plausible given that introduction to psychology students are taught early on that their discipline is a scientific one. The latter would ultimately influence the frequency with which they mentioned their discipline during the free listing task. Hence, this could have distorted the typicality scores of the discipline according to frequency and salience. Another possibility is that the features attributed to science were influenced by the fact that they were undergraduate psychology students performing a psychological experiment. Perhaps, in a more diverse sample, the feature “experiment” that was attributed to psychology would not have been evoked.

Nonetheless, it is important to note that most of the findings of the present research are similar to those of previous studies conducted in samples obtained from broader samples. For instance, this study found that psychology was perceived as one of the easiest disciplines. Keil et al. (2010) found the same phenomena in kindergarteners, children in grades 2, 4, 6, and 8, and in college students. Zimmerman et al. (2007) reached similar results in a sample of junior-high, high school, and college students. Additionally, this study found that psychology was perceived to be one of the least important disciplines. The same phenomenon was found by Krull and Silvera (2013) in college students. Still, an analysis of the typicality of the sciences performed exclusively on the subset of twenty participants from the Social Psychology Network found that psychology ranked eighth in the sciences typicality ranking instead of fourth with the full sample. Thus, it will be important for future research to consider the exploration of the conceptual representation of psychology with a more representative sample.

Future directions

The cognitive bias induced by categorization behavior on judgments about science can be further tested to explore practical implications. For example, future research could use the features of science (found in the present research) to be artificially presented in explanations of less typical sciences. Then, researchers could assess if in fact the stereotypical features influence participants to perceive the discipline as a better example of science. For example, future research could present psychological phenomena to participants in two different manners: with and without the presence of stereotypical features of science. That is, the experimental condition could consist in explanations of psychological phenomena that presented artificial and irrelevant information in the way of formulas, equations, or chemical terms. Then, typicality ratings of the sciences could be obtained to assess if the superficial manipulation of the features improved psychology's typicality among the sciences. If this result were found, it would have several practical implications. For example, knowledge about the influence of stereotypes of science on people's judgments could have a substantial impact in the courtroom (Satel & Lilienfeld, 2015).

Conclusion

The present study investigated whether categorization behavior influences the perception that psychology is unscientific. Hence, Experiments 1 and 2 systematically explored the conceptual representation of science and psychology. Chemistry, physics, engineering, and neurology were found to be the most typical sciences. Psychology's typicality score placed it relatively close to these more typical sciences. However, a careful analysis of the internal structure of the category *science* showed that psychology did not resemble the more typical sciences. This result may explain the skepticism about psychology's scientific status found in previous research. For example, studies have shown that psychology is perceived to be an unimportant,

easy, and unscientific discipline (Keil et al., 2010; Krull & Silvera, 2013). Moreover, its scientific explanations were perceived to be less satisfactory in comparison to explanations derived from the most typical sciences (Weisberg et al., 2008; Weisberg et al., 2015). Thus, the empirical evidence found by the present research supports the hypothesis that categorization behavior may be one of the cognitive mechanisms responsible of the perception of psychology as unscientific. In addition, the present research also provide evidence that it seems to be stereotypes rather than deliberate considerations of the scientific method that lead to people's representations of science.

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Appendix A: All the words mentioned in the free listing task

Num.	Item	Frequency (%)	Average Rank	Salience
1	Chemistry	86.5	3.78	0.657
2	Biology	81.3	2.72	0.694
3	Physics	76.6	4.60	0.525
4	Psychology	54.4	7.16	0.319
5	Neuroscience	49.1	7.19	0.264
6	Biochemistry	48	5.74	0.309
7	Mathematics	34.5	7.46	0.194
8	Sociology	28.7	8.65	0.136
9	Geology	28.1	6.83	0.162
10	Anthropology	26.9	9.20	0.111
11	computer_science	25.1	9.53	0.109
12	Astronomy	24.6	6.93	0.138
13	Engineering	24.6	6.90	0.128
14	Microbiology	24	7.10	0.134
15	Physiology	20.5	10.74	0.077
16	Genetics	19.9	8.59	0.102
17	Anatomy	18.1	11.48	0.072
18	Medicine	14.6	9.56	0.059
19	Geography	14	9.71	0.070
20	Ecology	12.9	9.64	0.056

21	organic_chemistry	12.9	6.95	0.078
22	cell_biology	12.3	7.43	0.069
23	Pharmacology	11.7	12.00	0.043
24	Immunology	11.7	7.95	0.065
25	cognitive_science	11.1	8.42	0.055
26	Astrophysics	10.5	9.78	0.045
27	environmental_science	8.8	9.60	0.034
28	cancer_biology	8.2	6.79	0.052
29	earth_science	7.6	7.62	0.039
30	Archaeology	7.6	9.38	0.037
31	Biophysics	7	12.25	0.025
32	Linguistics	7	8.75	0.031
33	Botany	7	11.67	0.023
34	Zoology	7	9.58	0.032
35	history	6.4	9.55	0.034
36	economics	6.4	10.55	0.029
37	philosophy	5.8	10.5	0.024
38	toxicology	5.8	14.9	0.014
39	nutrition	5.8	11.5	0.025
40	psychiatry	5.8	11.4	0.023
41	health_science	5.8	7.40	0.027
42	kinesiology	5.8	9.60	0.027

43	paleontology	5.3	14.22	0.014
44	marine_biology	4.7	12.13	0.017
45	oceanography	4.7	12.88	0.013
46	food_science	4.1	10.71	0.017
47	quantum_physics	4.1	7.71	0.023
48	physical_chemistry	4.1	9.86	0.015
49	political_science	4.1	9.57	0.015
50	mechanical_engineering	4.1	9.00	0.022
51	molecular_biology	4.1	8.86	0.024
52	pathology	4.1	9.43	0.017
53	nursing	4.1	9.43	0.016
54	biomechanics	4.1	10.29	0.019
55	biomedical	4.1	4.86	0.031
56	bioengineering	4.1	10.29	0.019
57	forensics	3.5	12.00	0.010
58	biotechnology	3.5	11.50	0.012
59	inorganic_chemistry	3.5	7.50	0.020
60	bacteriology	3.5	11.67	0.016
61	architecture	3.5	11.00	0.012
62	plant_biology	3.5	10.67	0.015
63	developmental_biology	3.5	8.67	0.017
64	statistics	3.5	9.83	0.014

65	chemical_engineering	2.9	8.00	0.015
66	electrical_engineering	2.9	8.60	0.012
67	meteorology	2.9	12.80	0.009
68	forensic_science	2.9	10.80	0.010
69	social_science	2.9	8.00	0.017
70	optics	2.9	11.60	0.008
71	astrology	2.3	6.50	0.013
72	natural_science	2.3	8.50	0.014
73	natural_history	2.3	7.00	0.013
74	nuclear_physics	2.3	10.00	0.008
75	neurobiology	2.3	11.00	0.009
76	human_kinetics	2.3	9.25	0.006
77	cardiology	2.3	9.75	0.009
78	morphology	2.3	16.75	0.005
79	life_science	2.3	9.50	0.011
80	parasitology	2.3	9.00	0.014
81	analytical_chemistry	2.3	12.5	0.008
82	theoretical_physics	1.8	10.00	0.007
83	genomics	1.8	8.67	0.007
84	metallurgy	1.8	12.67	0.007
85	oncology	1.8	5.67	0.010
86	micro_biology	1.8	5.33	0.010

87	radiology	1.8	12.00	0.008
88	mycology	1.8	12.33	0.007
89	cosmology	1.8	7.67	0.010
90	law	1.8	11.33	0.008
91	metabolism	1.8	8.33	0.006
92	thermodynamics	1.8	9.00	0.011
93	material_science	1.8	14.00	0.002
94	aerospace_engineering	1.8	8.00	0.011
95	literature	1.8	11.33	0.008
96	entomology	1.8	13.67	0.005
97	bioinformatics	1.8	13.33	0.006
98	dynamics	1.8	14.00	0.006
99	nanotechnology	1.8	11.33	0.008
100	mechanics	1.2	12.50	0.005
101	animal_biology	1.2	7.50	0.007
102	criminology	1.2	13.00	0.003
103	calculus	1.2	5.50	0.009
104	social_work	1.2	9.00	0.006
105	endocrinology	1.2	12.00	0.005
106	civil_engineering	1.2	9.50	0.007
107	health	1.2	12.50	0.001
108	health_psychology	1.2	7.00	0.006

109	biomedicine	1.2	7.00	0.006
110	volcanology	1.2	16.50	0.002
111	logistics	1.2	14.50	0.004
112	pediatrics	1.2	11.00	0.004
113	computer_engineering	1.2	7.00	0.006
114	animal_science	1.2	4.00	0.007
115	biomolecules	1.2	9.00	0.004
116	visual_arts	1.2	7.50	0.008
117	biostatistics	1.2	9.00	0.006
118	agriculture	1.2	15.50	0.002
119	information_technology	1.2	9.50	0.004
120	nanoscience	1.2	14.00	0.004
121	quantum_mechanics	1.2	7.50	0.005
122	biomedical_engineering	1.2	9.00	0.006
123	ophthalmology	1.2	11.50	0.003
124	environmental_chemistry	1.2	11.00	0.006
125	dentistry	1.2	15.50	0.002
126	evolution	1.2	6.50	0.008
127	social_psychology	1.2	3.50	0.010
128	virology	1.2	4.00	0.010
129	exercise_science	1.2	12.50	0.004
130	applied_physics	1.2	8.00	0.006

131	public_health	1.2	13.00	0.004
132	genetic_engineering	1.2	14.00	0.001
133	accounting	1.2	16.00	0.003
134	genealogy	1.2	12.50	0.005
135	nutrition_&_fitness	0.6	1.00	0.006
136	nutritional_science	0.6	9.67	0.001
137	blood	0.6	4.00	0.005
138	blood_pressure	0.6	9.00	0.004
139	pedagogy	0.6	16.00	0.001
140	optometry	0.6	14.00	0.001
141	viruse	0.6	16.00	0.001
142	osteology	0.6	8.00	0.003
143	orthology	0.6	20.00	0.000
144	veterinary_medicine	0.6	14.00	0.000
145	tube	0.6	5.00	0.005
146	pain	0.6	20.00	0.000
147	algebra	0.6	16.00	0.001
148	parent/guardian_phone_call	0.6	9.00	0.001
149	veins	0.6	13.00	0.002
150	trigonometry	0.6	12.00	0.003
151	nuclear_chemistry	0.6	16.00	0.001
152	spectrography	0.6	15.00	0.002

153	research_methods	0.6	4.00	0.003
154	research	0.6	16.00	0.001
155	robotics	0.6	7.00	0.001
156	school_community_service	0.6	4.00	0.004
157	s��curit��_interne	0.6	15.00	0.002
158	theology	0.6	7.00	0.004
159	religion	0.6	13.00	0.002
160	punishment_as_beating	0.6	3.00	0.003
161	quantile	0.6	8.00	0.001
162	public_apology	0.6	5.00	0.004
163	suspension	0.6	2.00	0.005
164	abnormal_psychology	0.6	2.00	0.005
165	structural_biology	0.6	17.00	0.001
166	space_science	0.6	5.00	0.001
167	sicpline	0.6	7.00	0.004
168	social	0.6	7.00	0.001
169	systems_biology	0.6	16.00	0.001
170	social_and_behavioral	0.6	11.00	0.002
171	social_and_behavior al_health	0.6	2.00	0.005
172	perception	0.6	13.00	0.002
173	biological_life	0.6	2.00	0.005
174	pharmaceutical_chemistry	0.6	19.00	0.001

175	phlebotomy	0.6	15.00	0.001
176	physical_science	0.6	6.00	0.004
177	aeronautics	0.6	18.00	0.001
178	perinatology	0.6	9.00	0.003
179	pharmaceutical	0.6	9.00	0.004
180	personality_psychology	0.6	8.00	0.003
181	thermonuclear_astrophysics	0.6	15.00	0.002
182	psychobiology	0.6	12.00	0.003
183	privilege_withdrawal	0.6	10.00	0.001
184	biometrics	0.6	20.00	0.000
185	protoscience	0.6	12.00	0.003
186	pseudoscience	0.6	17.00	0.000
187	pills	0.6	15.00	0.002
188	plant_pathology	0.6	15.00	0.002
189	thermomechanics	0.6	17.00	0.001
190	police_studies	0.6	14.00	0.002
191	plant_science	0.6	9.00	0.001
192	plants	0.6	18.00	0.001
193	chemical_kinetics	0.6	15.00	0.002
194	etymology	0.6	17.00	0.001
195	ethnology	0.6	18.00	0.001
196	evolutionary_biology	0.6	13.00	0.001

197	experimental_physics	0.6	6.00	0.003
198	expulsion	0.6	3.00	0.005
199	environmental_engineering	0.6	8.00	0.003
200	astrobiology	0.6	6.00	0.002
201	ethics	0.6	19.00	0.001
202	arithmetic	0.6	7.00	0.004
203	epidemiology	0.6	16.00	0.001
204	electronics	0.6	1.00	0.006
205	forestry_science	0.6	11.00	0.003
206	forensic_psychology	0.6	11.00	0.002
207	functions	0.6	4.00	0.005
208	fundamental_forces	0.6	1.00	0.006
209	fighting	0.6	1.00	0.006
210	firefighter	0.6	5.00	0.001
211	finance	0.6	6.00	0.002
212	forensic_medicine	0.6	9.00	0.004
213	food_and_nutrition	0.6	14.00	0.002
214	chemical	0.6	7.00	0.004
215	applied_science	0.6	9.00	0.004
216	behaviorism	0.6	1.00	0.006
217	cognitive_psychology	0.6	3.00	0.004
218	computational_biochemistry	0.6	6.00	0.004

219	computer_programming	0.6	7.00	0.003
220	consciousness	0.6	14.00	0.002
221	behavior al_science	0.6	9.00	0.004
222	chemist	0.6	1.00	0.006
223	cognitive_neuroscience	0.6	4.00	0.003
224	class/assignment_failure	0.6	8.00	0.002
225	clinical_psychology	0.6	5.00	0.003
226	electrochemistry	0.6	19.00	0.000
227	docked_marks	0.6	6.00	0.003
228	do_strong_work	0.6	2.00	0.004
229	ear	0.6	18.00	0.001
230	bacteria	0.6	17.00	0.001
231	criminal_psychology	0.6	6.00	0.002
232	demography	0.6	6.00	0.004
233	cultural_psychology	0.6	7.00	0.001
234	developmental_psychology	0.6	10.00	0.002
235	dermatology	0.6	7.00	0.001
236	detention	0.6	1.00	0.006
237	nerve_system	0.6	12.00	0.003
238	medical_chemistry	0.6	7.00	0.001
239	meddicine	0.6	4.00	0.003
240	medical_ethics	0.6	13.00	0.002

241	medical_physics	0.6	8.00	0.002
242	mental_health	0.6	5.00	0.004
243	lose_freedom	0.6	1.00	0.006
244	logic	0.6	4.00	0.004
245	marine_science	0.6	12.00	0.003
246	macrobiology	0.6	2.00	0.005
247	biogeography	0.6	17.00	0.001
248	animals	0.6	17.00	0.001
249	muscles	0.6	11.00	0.003
250	molecular_science	0.6	7.00	0.002
251	natural	0.6	7.00	0.001
252	neonatology	0.6	16.00	0.001
253	metaphysics	0.6	6.00	0.003
254	military_science	0.6	19.00	0.001
255	ancient_science	0.6	8.00	0.002
256	molecular_ecology	0.6	16.00	0.001
257	minerology	0.6	15.00	0.000
258	brain	0.6	1.00	0.006
259	geomatics	0.6	18.00	0.001
260	herbology	0.6	4.00	0.003
261	heart_attack	0.6	10.00	0.003
262	cell_biochemistry	0.6	12.00	0.003

263	hormones	0.6	14.00	0.002
264	human_nutrition	0.6	9.00	0.001
265	grade_year_repetition	0.6	7.00	0.002
266	geophysics	0.6	5.00	0.004
267	heart	0.6	8.00	0.004
268	gynecology	0.6	15.00	0.000
269	health_studies	0.6	13.00	0.002
270	limnology	0.6	11.00	0.003
271	it	0.6	7.00	0.003
272	infection	0.6	19.00	0.001
273	killing_prisoner	0.6	4.00	0.001
274	legal_medicine	0.6	12.00	0.003
275	humanities	0.6	11.00	0.003
276	hydrology	0.6	8.00	0.004
277	hydraulics	0.6	14.00	0.002
278	applied_chemistry	0.6	9.00	0.002
279	immunity	0.6	17.00	0.001
280	immunobiology	0.6	8.00	0.003

Appendix B: Saliency calculations

In a set of free-list data, it is possible to obtain an index that is designed to take into account both the frequency and rank order of items in the lists (Smith & Borgatti, 1998).

The formula is:

$$S = ((\sum (L - R_i + 1)) / L) / n$$

s = the average rank of an item across all lists in the sample, weighted by the lengths of the lists in which the item actually occurs.

L = the length of (number of items in) a list.

R_i = the rank of item i in the list (first = 1).

n = the number of lists in the sample.

Appendix C: All the word mentioned for all the disciplines by at least 10% of participants.

Discipline	Number of features mentioned	Feature	Frequency of mention (%)
Anthropology	1	humans	61.4
	2	culture	45.5
	3	evolution	31.8
	4	history	22.7
	5	animal	15.9
	6	group	15.9
	7	bones	13.6
	8	development	13.6
	9	study	13.6
	10	society	13.6
Astronomy	1	stars	91.3
	2	planet	71.7
	3	space	69.6
	4	moon	41.3
	5	telescope	32.6
	6	galaxy	30.4
	7	universe	30.4
	8	constellation	23.9
	9	physics	21.7

	10	sun	19.6
	11	comets	15.2
	12	science	10.9
	13	black_hole	10.9
	14	milky_way	10.9
	15	earth	10.9
	16	solar_system	10.9
	17	meteor	10.9
	1	animal	56.1
	2	plants	43.9
	3	science	39.0
	4	humans	24.4
	5	life	24.4
	6	evolution	24.4
	7	organisms	22.0
	8	body	22.0
	9	cell	19.5
Biology	10	genetics	19.5
	11	dissection	17.1
	12	labs	17.1
	13	chemistry	14.6
	14	ecosystems	14.6

Chemistry	15	Anatomy	12.2
	16	Experiment	12.2
	1	Science	49.0
	2	Chemicals	42.9
	3	Reactions	34.7
	4	Experiment	34.7
	5	Elements	32.7
	6	Labs	30.6
	7	Atoms	26.5
	8	periodic_table	24.5
	9	Mathematics	22.4
	10	Equation	20.4
	11	Molecules	18.4
	12	Matter	14.3
	13	Solid	12.2
	14	Mixtures	12.2
	15	Liquid	12.2
	16	Moles	12.2
	17	Bonds	12.2
	18	Gas	10.2
	19	Difficult	10.2
	20	Compounds	10.2

	21	acids	10.2
Computers	1	technology	46.2
	2	programming	30.8
	3	internet	23.1
	4	keyboard	23.1
	5	software	23.1
	6	screen	20.5
	7	hard_drive	17.9
	8	difficult	15.4
	9	science	15.4
	10	coding	15.4
	11	game	15.4
	12	intelligence	12.8
	13	mathematics	12.8
	14	computer_science	12.8
	15	fast	10.3
	16	engineering	10.3
	17	mouse	10.3
	18	design	10.3
Engineering	1	mathematics	70.0
	2	building	35.0
	3	science	35.0

	4	physics	32.5
	5	intelligence	30.0
	6	difficult	27.5
	7	mechanical	20.0
	8	civil	20.0
	9	electrical	15.0
	10	design	12.5
	11	calculation	12.5
	12	construction	12.5
	13	number	12.5
	14	chemicals	12.5
	15	equation	10.0
	16	aerospace	10.0
	17	structure	10.0
	18	bridge	10.0
	19	chemistry	10.0
	20	technology	10.0
Geography	1	map	63.4
	2	land	39.0
	3	countries	36.6
	4	earth	31.7
	5	rocks	26.8

	6	World	26.8
	7	Ocean	24.4
	8	Continent	22.0
	9	Location	22.0
	10	Longitude	17.1
	11	Water	17.1
	12	Mountain	14.6
	13	Weather	14.6
	14	Volcano	14.6
	15	Latitude	14.6
	16	Science	12.2
Mathematics	1	Number	62.8
	2	Equation	55.8
	3	Difficult	37.2
	4	Addition	37.2
	5	Multiplication	32.6
	6	Division	32.6
	7	Subtraction	32.6
	8	Statistics	25.6
	9	Algebra	25.6
	10	Calculation	16.3
	11	Calculus	16.3

	12	calculator	14.0
	13	graph	11.6
	14	trigonometry	11.6
Medicine	1	doctor	63.0
	2	helping_people	30.4
	3	hospital	28.3
	4	health	26.1
	5	drug	21.7
	6	biology	21.7
	7	nurse	21.7
	8	surgery	17.4
	9	chemistry	15.2
	10	chemicals	15.2
	11	cure	15.2
	12	treatment	15.2
	13	life	15.2
	14	science	15.2
	15	pill	15.2
	16	difficult	13.0
	17	education	13.0
	18	needle	13.0
Neurology	1	brain	92.5

	2	neuron	30.0
	3	science	30.0
	4	biology	25.0
	5	nervous_system	20.0
	6	disorder	15.0
	7	spinal_cord	15.0
	8	difficult	15.0
	9	chemicals	15.0
	10	scan	15.0
	11	humans	12.5
	12	medicine	12.5
	13	thinking	12.5
	14	behavior	12.5
	15	hormone	10.0
	16	surgery	10.0
	17	doctor	10.0
	18	psychology	10.0
	19	treatment	10.0
	20	functions	10.0
	21	synapse	10.0
	22	chemistry	10.0
Physics	1	mathematics	47.4

	2	Science	42.1
	3	Difficult	34.2
	4	Forces	26.3
	5	Space	26.3
	6	Gravity	21.1
	7	Equation	21.1
	8	Time	18.4
	9	Matter	15.8
	10	Energy	15.8
	11	Intelligence	15.8
	12	Light	15.8
	13	Motion	13.2
	14	Law	13.2
	15	Movement	10.5
	16	Mass	10.5
	17	Experiment	10.5
Psychology	1	Brain	54.8
	2	Behavior	50.0
	3	Mind	40.5
	4	Cognition	21.4
	5	Humans	21.4
	6	Research	19.0

	7	freud	19.0
	8	mental_health	19.0
	9	thinking	16.7
	10	theory	16.7
	11	therapy	14.3
	12	disorder	14.3
	13	personality	14.3
	14	development	11.9
	15	experiment	11.9
	16	social_science	11.9
Sociology	1	society	64.3
	2	humans	42.9
	3	behavior	40.5
	4	interactions	23.8
	5	development	21.4
	6	culture	14.3
	7	group	11.9
	8	social_science	11.9
	9	gender	11.9

Appendix D: Scientific Literacy Test

First section. General Scientific Knowledge.

This section will be answered on a 4-point Likert Scale (i.e., True, Unsure but I think it's true, Unsure but I think it's False, and False).

Items:

- The oxygen that we breathe comes from plants.
- Lasers work by focusing sound waves.
- Electrons are smaller than atoms.
- The universe began with a huge explosion.
- The continents on which we live have been moving apart for millions of years, and will
- continue to move in the future.
- The earliest humans lived at the same time as the dinosaurs.
- Light travels faster than sound.
- On average, it takes 28 days for the earth to make a full orbit around the sun.
- Radioactive milk can be made safe by boiling it.
- Sunlight can cause skin cancer.
- Hot air rises.
- The liver makes urine.
- Antibiotics kill viruses as well as bacteria.
- Most people use only 10% of their brain's processing capacity.
- Opposites attract: people are typically attracted to partners who differ from them.
- Human memory works like a video or tape recorder.

- The psychiatric disorder known as autism is caused by prior exposure to mercury-based
- vaccines.

Second section. Knowledge of Methodology

Mainly, this section will consist of some questions to be answered on a 4 point Likert Scale (i.e., True, Unsure but I think it's true, Unsure but I think it's False, and False). Some of the question in this section will have different options.

1. Scientists tend to weigh evidence in support of a theory more strongly than evidence produced against it.
2. Susan has noticed that none of the people in her life who smoke have suffered cancer. Instead, she notes that everyone she knows who has suffered the disease, was a non smoker. Susan is right to conclude that smoking does not cause cancer, regardless of contradictory scientific findings.
3. Mary conducts analyses using a statistical software program and finds that the rising incidence of divorce has a strong relationship with the rising gas prices. Mary can now conclude that divorce is caused by an increase in gas prices.
4. Dr. Albert has recruited participants for his study on the effects of having a pet on Post Traumatic Stress Disorder (PTSD). Eleven people took part in the experiment, three of which suffered from PTSD. One of the participants with PTSD already had a dog and one had a pet fish. Dr. Albert found that the participants with pets were less likely to experience a high physiological stress response to trauma-related cues. Dr. Albert is right in concluding that having a pet has positive therapeutic effects on PTSD.

5. Your favorite hockey player has not scored a goal over the last nine games. If it is assumed that he has a 50:50 chance of either scoring a goal or not in each game, it can be concluded that there is an increased likelihood that he will score a goal in the next game.

6. A company has developed a diet pill that helps people feel less hungry. To support the statement that this pill leads people to lose weight, one hundred people are asked to take it daily and to follow a diet that reduces calorie intake by 20%. At the end of one month, 88 people in the sample out of 100 lost 5 or more pounds. Hence, the company claimed that the pill had worked as intended. Would scientists believe that this experience had produced strong support for efficacy of this weight loss pill?

a. Yes

b. No

7. Suppose a drug used to treat high blood pressure is suspected of not working well. The following is a list of three different ways scientists might use to investigate the problem. Which one do you think scientists would be most likely to use?

a. Talk to patients to get their opinions

b. Use their knowledge of medicine to decide how good the drug is

c. Give the drug to some patients by not to others. Then compare what happens to each group.

8. When scientists talk about Einstein's theory of relativity, scientists are talking about

a. A hunch or idea

b. A well established explanation

c. A proven fact

9. A doctor tells a couple that they have a one in four chance of having a child with an illness.

Does this mean that,

- a. If they have only three children, none will have the illness?
- b. If their first child has the illness, the next three will not?
- c. Each of the couple's children will have the same risk of suffering the illness?
- d. If the first three children are healthy, the fourth will have the illness?

10. When scientists talk about Newton's First Law, scientists are talking about

- a. A hunch or idea
- b. A well established explanation
- c. A proven fact

11. When scientists discuss hypotheses, scientists are talking about

- a. A hunch or idea
- b. A well established explanation
- c. A proven fact

Third section. Attitudes Toward Science

The following questions should be given on a 5-point Likert scale (Strongly Agree, Agree, No Opinion, Disagree, and Strongly Disagree).

- 1. All of today's scientific theories will still be accepted in a hundred years' time.
- 2. Natural vitamins are better for you than laboratory-made ones.
- 3. There are phenomena that physical science and the laws of nature cannot explain.
- 4. The positions of the planets have an influence on the events of everyday life.
- 5. UFOs are real and should be investigated.

6. Some people possess psychic powers.
7. Nuclear power is an important energy source and its use should be expanded.
8. Some ancient civilizations were visited by extraterrestrials.
9. Computers will eventually be intelligent enough to think like humans.
10. Scientists should take responsibility to the bad effects of their theories and inventions.
11. The government should strongly support the manned space program.
12. Genetic engineering is a good idea.
13. We should devote more of our money and scientific resources to repair damage done to the environment.
14. Pure science should be funded regardless of its lack of immediate benefit to society.
15. Science will come up with a way to dispose of toxic waste.
16. Faith healing is a valid alternative to conventional medicine.
17. We should make a concerted effort to search for life on other planets.
18. Scientists should be allowed to do research that causes pain to animals, if it helps solve human health problems.
19. Some numbers are especially lucky for some people.
20. Theories founded in psychology can be attributed to common sense.