Cognitive Psychology, 15, 1–38.
Inhelder, B. and Piaget, J. 1958: *The Growth of Logical Thinking*. New York: Basic Books.
Johnson-Laird, P.N. 1983: *Mental Models*. Cambridge: Cambridge University Press.
Newell, A. and Simon, H.A. 1972: *Human Problem Solving*. Englewood Cliffs, N.J.: Prentice-Hall.
Rips, L.J. 1983: Cognitive Processes in Propositional Reasoning. *Psychological Review*, 90, 38–71.
Rumelhart, D., Smolensky, P., McClelland, J.L. and Hinton, G.E. 1986: Schemata and Sequential Thought Processes in PDP Models. In J.M. McClelland, & D. Rumelhart (eds.) *Parallel Distributed Processing: Explorations in the Microstructure of Cognition. Volume 2: Psychological and Biological Models.* Cambridge, MA: MIT Press.

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Forum
5. Concepts and Correct Thinking

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The problem of normativity posed by the 'old-fashioned philosopher' appears to threaten the very existence of a scientific psychological approach to concepts. Philosophers tell us that human kind is rational, and can appreciate the necessity of logical truths. Psychologists have demonstrated in a hundred different ways that the human species is liable to behave in a basically irrational manner, if let loose on an actual problem. (Indeed the psychological journals are rarely interested in studies demonstrating successful normative thinking! Good news is no news.) How can we resolve the paradox of these two views? How can we be at the same time rational as the observers developing our science of behaviour, and irrational as the subjects of the observations? Is there room for normative rationality within cognitive psychology? The paradox is by no means confined to the domain of concepts. Other areas of cognition have also been a source of debate about the resolution of the descriptive and the prescriptive.

The problem of normative rationality is most familiar to psychologists in the domain of reasoning. Evans 1982, Johnson-Laird 1983, Wason 1968, and many others (e.g. Tversky and Kahneman 1974) have demonstrated that in many tasks requiring logical thought, people reason using a variety of pragmatic schemas and non-logical heuristics based on earlier experience. They do not follow the prescriptive forms of logical reasoning, except as it were by accident when the fit between the normative and their own system happens to be good.

Psychology can offer an account of why people are illogical in their reasoning in terms of a variety of processing limitations. In his book *Epistemology and Cognition*, Goldman 1986 attempts to justify the basic rationality of man, by extending the notion of 'rationality' to encompass such additional ecologically adaptive features as the ability to think quickly, and to minimise the most dangerous kinds of errors. A perfectly logical system for decision making will be of little use if it can't compute answers to pressing problems in time to take the necessary actions. The brain has evolved as a messy mixture of heuristic strategies for getting quick and dirty answers to real life problems (see Clark 1987). The result, Goldman argues, is that rationality could be defined in terms of adaptation. Survival is the only key to what is rational. One is then led to several philosophically distasteful conclusions—for instance that selfless behaviour is irrational, and that an illogical inconsistent system of thought may in the right circumstances be more rational than one that is logical and consistent. What is more, the problem still remains of how (and why) we are able to appreciate logical thought at all, given the nature of our preferred modes of thinking.

The problem with normative reasoning as identified with traditional logic, is that logic often has difficulty in interfacing with the world. To be effective in achieving true conclusions, we must first have a vocabulary that maps unambiguously onto the world. We must have premisses with clear truth values, and syntactic constructions with unambiguous logical structure. Logic applies to an idealization of the world. Henle's attempts to evoke syllogistic reasoning in conversation-like vignettes (Henle 1962) showed that the logic of an argument is almost entirely lost to view when subjects are faced with 'life-like' problems. Everyday situations where we have to reason rarely provide the necessary starting point for logic to work its wonders. Sherlock Holmes' celebrated use of pure reasoning, when examined closely, turns out to be an elaborate fabrication of supposition and unsupported conjecture. Equipped with a fertile imagination for generating possible scenarios, he plays the probabilities, which (with the author's help) generally turn out to be correct. In the real world there is almost never a situation where having ruled out the impossible there is only one remaining alternative (however improbable). Problems are open ended, and there is always some additional factor which can be supposed to have intervened.

Given that people apparently rarely refer to logical rules when reasoning, the puzzle of normativity could be restated as where our intuitions about the validity of logic come from—how does our ability to appreciate logical argument arise, if it is not in our normal behavioural repertoire? Among psychologists, the person who was most particularly concerned with this question was Jean Piaget. His psychology of adult cognition over-idealized intelligence and did little to explain the facts about adult reasoning. However the basic question that he posed remains. For example, how do we arrive at the apparently unshakeable intuition of the necessary truth of such equations as (1)?

$$(1)\ A \times B = B \times A$$

Is it by computing each side of the equation with many different values, and demonstrating that there is never a counterexample? Surely this alone could not explain the sense of necessity. It seems rather that we have

a higher level of understanding that some operations are commutative. Furthermore we may have a further belief that if an operation is non-commutative then this will be immediately evident. Having identified that multiplication is commutative for a range of different cases, we jump to the conclusion that it will always be so.

If we want further support for the belief, we might also observe that if $A \times B$ is taken as the area of a rectangle of sides A and B, then the equation (1) states the 'self-evident' truth that the area of a rectangle remains the same when it is rotated through ninety degrees. (This belief lends reciprocal support for the definition of the area of a rectangle as the product of the two dimensions.) There is a coherent web of uses for the operation, all of which support the commutativity assumption. Equation (1) is a part of a group of operations that form a consistent and self-contained set of transformations. For Piaget it is the interlocking nature of the concepts that provides the sense of certainty and necessity. If (1) were *false*, then the consequences would undermine a large number of other truths forming the whole system of understanding. A sense of normativity therefore comes from the deeply embedded nature of some beliefs. They cannot be shaken, because to deny them would be to introduce a flaw into the whole structure of our adaptive intelligence. The whole edifice of our understanding of the domain in question would collapse. Murphy and Medin 1985 make the point that concepts are deeply embedded in theoretical understanding of the world. The theories that we hold to are constituted from our concepts, but also validate those concepts.

The possibility then still remains that an alternative construction of reality would be feasible. Some completely different set of fundamental axioms and theories about the world may form an equally self-consistent structure of understanding, and may fit the evidence equally well. (Some have argued that certain forms of madness show this possibility.) Our common biological nature and our common physical and social environment make such alternative 'realities' unlikely. However creatures from another world, equipped with different senses, and with different interests and modes of social interaction could conceivably possess a radically different understanding of reality. In such a case, the normativity of our concepts would be shown to be relative. Rationality as we understand it would only be normative for humans.

Consider another of the conceptual advances in childhood made famous by Piaget—conservation. How do we come to be convinced that the volume of water in two beakers remains equal when the contents of one are poured into a third beaker that is higher but narrower? By the age of 9 (and often earlier) a child has an unshakeable conviction that it must necessarily be so. Focussing on the group of mental operations involved, Piaget argued that for conservation to be acquired, a child has to grasp three principles. These principles are those of identity (the object has not been changed—nothing added or taken away), compensation (increases in one dimension are compensated for by decreases in another), and reversibility (the transformation can be reversed to reinstate the original demonstrable equality of the liquids). The salience of these principles for establishing conservation can be demonstrated by showing that adults will use them to guide the conservation of other dimensions under similar transformations. According to Piaget the sense of (almost logical, or ontological) necessity attached to conservation comes from these operations which have become so deeply entrenched in our understanding of the world as to form part of the unquestionable presupposed basis of all thinking.

Unfortunately there is nothing in Piaget's rules to confer the status of rationality on the resulting intellectual system. As an example consider the case of the area enclosed within a piece of string of fixed length, as it is stretched over four pegs to make a square. As the pegs are adjusted to form the string into a more rectangular shape, it has been shown that many adults believe that the area remains constant (whereas in fact it is the circumference that remains constant, while the area decreases since $(a-b).(a+b) = a^2-b^2$ which must necessarily be less than a^2, the area of the square). Notice that the three principles of identity, compensation and reversibility all apply to this transformation. The fact that the conservation response is incorrect demonstrates that Piaget's analysis of rationality in terms of systems of operations falls short of establishing a normative basis for thought. As with all logic, it does not provide a way of discriminating those situations where it applies from those where it does not. A person must somehow first know that a relation obeys certain logical principles. Only then can the axioms and apparatus of the logic drive reasoning.

If appeal to reversibility and the rest does not convey rationality, then how do we come to the conclusion that liquid volume is conserved? The answer must be that it is an empirically derived conclusion. If we want to talk and think about the amount of stuff in a beaker, there are various ways in which the concept of 'amount' can be operationalised. None of them is the 'correct' way. They are equally correct concepts of amount. We could for example define the volume of a cylindrical beaker of height H and radius R as being H+2R, or perhaps H×2R. We could even define it in terms of some non-standard way of combining the two dimensions. An intuitively reasonable constraint on the definition of amount could perhaps be that it should increase monotonically with increases in each dimension, when the other is held constant. This constraint could be derived from a wide range of similar quantitative concepts, such as area, mass, and number. The constraint however still leaves an infinite number of possible functions for combining the measurable linear dimensions into a measure of volume, and a great many of these are psychologically quite reasonable. What makes πHR^2 the 'normatively correct' definition for the volume of a cylinder is that it can do certain things which other quantitative concepts cannot. For instance it can be derived from the more general concept that areas can 'sweep out' volumes when a plane figure is moved perpendicular to the plane. The normative definition thus uses the same formula of Volume=Height × Base area, which can be applied to innumerable other

shapes whose sides make a right angle with their bases. (The definition of the area of a circle depends on further interlocking notions of area.) Most importantly, the normative definition of volume gives a number which *does* remain constant when liquid is poured from one shaped container into another—not only when the other is cylindrical, but also when it is a box shape, or a hemisphere, or any other container with defined dimensions. Thus the combination of our definition of volume, plus the assumption of conservation, permits us to predict just how full any particular jar will be when water is poured into it from some other standard beaker, and these predictions turn out to be correct.

Finally, the constancy of this number fits with concepts that we have about the actual nature of the stuff of which the world is composed. Liquids may be understood naively as being like collections of very tiny beads. Since the numerosity and the size of the beads remains constant as they are transferred from one container to another, so the space they occupy should remain constant (this of course is not true—the beads can be packed in more or less space-saving formations). Liquids are thought of as non-compressible (and we may have some evidence from our experience that they differ from gases in this respect). Volume conservation fits an intuitive theory of the molecular/atomic nature of matter.

Normative definitions give us tremendous increase in the power of our concepts—we can link them all together with cross derivations. They form a consistent system. They match the world in allowing a quantity to be defined which is conserved under a certain range of transformations, thus allowing for prediction, and they are consistent with other theoretical beliefs we have about the nature of matter, such as the non-compressibility of liquids. What remains a mystery is how children are able to arrive at conservation at a relatively early age—certainly without any direct empirical testing of mathematical formulae for volumes, or any proper understanding of the molecular nature of matter. Children (and adults without training in physics) must presumably base their concept of volume on the logically less accurate, but psychologically more compelling evidence of Piaget's three principles, and on the generality of conservation beliefs across a wide range of quantitative dimensions, such as length, number, mass, weight, volume and area.

The psychologist then has two issues to explore. First how do children arrive at concepts for understanding the world, which they carry with them into adulthood—that is what are the inductive principles that lead to the choice of quasi-quantitative concepts that support conservation of quantity under transformation? Second, how do physicists arrive at the idea of normatively correct concepts for understanding the world, and what justification do they have for claiming that their concepts are better or more correct? I would claim that both of these issues are the proper subject for psychological investigation. The question of how beliefs and theories are formed and defended is primarily an issue for psychology and the social sciences.

It should be clear from this discussion, that I would argue that we cannot assume that there are any universally normative concepts. There are only concepts that are more or less useful for particular purposes. A concept of volume that allows for a mathematically consistent definition to be given across a range of regular shapes, and which also allows for the value of a particular measure to remain constant under different transformations is much more useful as a measuring tool, and as a component in physical theories (such as the Laws governing the volume, temperature, and pressure of gases, for example). However its claim to be normative and rational is only one of degree. Concepts are formed as part of theoretical understandings. They succeed only to the extent that the theory of which they are a part succeeds. Einsteinian relativity demanded radical changes in the traditional scientific concepts of mass, length and time. The shortest distance between two points may not be a straight line. Two events may be simultaneous to one observer, but not to another. The famous thought experiments of Einstein and other modern physicists are paradigm cases of conceptual change, where concepts previously held to be absolute, normative and rational ways of understanding the world were challenged and overthrown.

I have so far described a basis for normativity in terms of what psychological processes lead us to prefer certain concepts over others. This principle could then lead us, following Putnam, to define normative concepts as the (imagined) end goal of our present scientific advance. The *correct* concept of space will be whatever concept plays a part in the final scientific theory that explains all known phenomena that are discoverable by the human senses and their extensions.

One can accept this optimistic view without unduly undermining the scientific psychological study of concepts. The psychologist is the one who must explain what it is to have a theory, and what criteria people use to determine that one theory is preferable to another. The psychology of concepts wil be describing each stage of the process of scientific advance, indicating the adaptive value for the purposes of science of taking one view of nature rather than another. I describe this view of normativity as optimistic however, because it appears to presume that there is in fact an end to scientific advance. The creator made things in just such a way as we would be able to understand. Should the universe turn out in the end to be unknowable and unexplainable within the limits of human intelligence, we would on this view have to admit that there never were any concepts at all—in the normative sense of 'correct' concepts. Taking a 'God's eye view' position on normative concepts leads to the danger of being left with no theory, should God turn out not to exist after all.

There is no *absolute* system for classifying the world—classifications are only correct for a particular purpose. When hungry I classify the animal and plant kingdom into the edible raw, the edible cooked, and the inedible. This is the correct way to classify for this purpose. Scientists may claim to have a higher purpose—to discover what really is the case, and so may

claim that their classifications are the superior, or the correct ones. But the classifications do no more than to serve the scientists' purpose. It may suit botanists to classify cucumbers and red peppers as fruits, but to demand that the layman also see the world in the same light smacks of conceptual imperialism. We most probably have many alternative, partially interlocking sets of conceptual theories, each of which has evolved to serve a particular function in our lives (see for example, Lakoff's analysis of idealised cognitive models as an example of how different conceptualizations interact within the same language term to yield vagueness and prototype effects, Lakoff 1987). We may be able to define criteria of completeness, consistency and external validity to allow us to prefer one conceptual structure over another, within one domain (such as understanding the physical world—this is after all the basis of advance in science). However, in general, we are always going to need a variety of ways of understanding—to deal with the whole variety of our experiences and goals. The criteria for normativity in science may well not match the criteria for normativity in other areas of our lives—aesthetic and moral criteria may be required. Achieving a full understanding of normativity depends on an analysis of how conceptual systems achieve internal strength and external validation. This analysis is an empirical venture, the subject of which is human thought—as exhibited not by 'naive' subjects, but by those trained to reason in a normative way. What we need is not just a philosophy of psychology—it is a psychology of philosophy.

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References

Clark, A. 1987: The Kludge in the Machine. *Mind and Language*, 2, 277–300.

Evans, J.St.B.T. 1982: *The Psychology of Deductive Reasoning*. London: Routledge and Kegan Paul.

Goldman, A. 1986: *Epistemology and Cognition*. Cambridge, MA: Harvard University Press.

Henle, 1962: On the Relation Between Logic and Thinking. *Psychological Review*, 69, 366–378.

Johnson-Laird, P.N. 1983: *Mental Models*. Cambridge: Cambridge University Press.

Lakoff, G. 1987: *Women, Fire, and Dangerous Things*. Chicago: Chicago University Press.

Tversky, A., and Kahneman, D. 1974: Judgment Under Uncertainty: Heuristics and Biases. *Science*, 185, 1124–1131.

Wason, P.C. 1968: Reasoning About a Rule. *Quarterly Journal of Experimental Psychology*, 20, 273–281.