



Article scientifique

Article

2011

Published version

Open Access

This is the published version of the publication, made available in accordance with the publisher's policy.

Dual-process theories and cognitive development: Advances and challenges

Barrouillet, Pierre Noël

How to cite

BARROUILLET, Pierre Noël. Dual-process theories and cognitive development: Advances and challenges. In: Developmental review, 2011, vol. 31, n° 2/3, p. 79–85. doi: 10.1016/j.dr.2011.07.002

This publication URL: <https://archive-ouverte.unige.ch/unige:18389>

Publication DOI: [10.1016/j.dr.2011.07.002](https://doi.org/10.1016/j.dr.2011.07.002)



Contents lists available at [SciVerse ScienceDirect](#)

Developmental Review

journal homepage: www.elsevier.com/locate/dr



Dual-process theories and cognitive development: Advances and challenges

Pierre Barrouillet

Université de Genève, Faculté de Psychologie et des Sciences de l'Education, 40 bd du Pont D'arve, 1211 Genève 4, Switzerland

ARTICLE INFO

Article history:

Available online 9 September 2011

ABSTRACT

Dual-process theories have gained increasing importance in psychology. The contrast that they describe between an old intuitive and a new deliberative mind seems to make these theories especially suited to account for development. Accordingly, this special issue aims at presenting the latest applications of dual-process theories to cognitive development. Dual-process theoreticians mainly focused on adult functioning have been invited to elaborate the developmental implications of their theory, while developmental psychologists who have proposed dual-process theories of development in the domain of thinking and reasoning present the most recent formulation of their theory and review supporting empirical evidence.

© 2011 Elsevier Inc. All rights reserved.

Introduction

The emergence of the psychology of reasoning during the latter half of the last century – especially Peter Wason's pioneering work – led to questioning of the widely held assumption that, when asked to do so, adults reason in a way that conforms to the prescriptions of logic. Well-educated adults erred in selecting the information needed to verify simple conditional sentences, and did not prove wiser in testing hypotheses (Wason, 1960, 1966). These findings were at odds with the prevailing Piagetian conception of a formal operational stage in which cognitive structures isomorphic to formal logic governed adult reasoning (Inhelder & Piaget, 1958). Further investigations revealed a series of biases in human reasoning (Evans, 1989), such as the belief, confirmation, matching, or conclusion biases described by Manktelow (1999, p. 64) as any 'systematic tendency which is independent of what a relevant normative theory would endorse'. The famous studies by Kahneman and Tversky on judgment and decision making (Kahneman, Slovic, & Tversky, 1982) completed the portrait of reasoning

E-mail address: Pierre.Barrouillet@unige.ch

driven by a set of heuristics that departs from any logic or normative theory. Overall, the so-called 'heuristics and biases' literature deeply disconfirmed the presumed rationality of adult human beings.

Though these pessimistic conclusions were drawn from well-controlled and carefully designed experiments, they nonetheless constituted a kind of paradox. Indeed, how could human beings be so biased and illogical in their reasoning and decisions and at the same time be able to put a man on the moon and bring him back home? Moreover, the presumption of rationality in adults was not uniquely based on mere presuppositions and beliefs. A venerable scientific tradition, initiated by Piaget, also based on well-controlled and carefully designed studies, has provided ample evidence that cognitive development can be described as a growth in reasoning capacities and rationality, from the intuitions that characterize children's thinking to adult's reasoning that often conforms to the prescriptions of logic (Bjorklund, 2005; Morra, Gobbo, Marini, & Sheese, 2008). As Reyna and Brainerd cogently note in this issue, the logical adult of developmental theories does not resemble the intuitive adult of the 'heuristics and biases' literature. It is this paradox that dual-process theories were aimed at resolving. Dual processing accounts of reasoning, judgment, and social cognition are so abundant in the literature that Evans (2008) judged the task of drawing some coherent overview of this topic to be complex and challenging.

Despite their diversity, all the different dual-process theories that have been put forward assume that two types of processing coexist in the mind, with different evolutionary histories, different functioning, and possibly distinct cerebral substrates (Epstein, 1994; Evans, 2006; Evans & Over, 1996; Slovic, 1996; Stanovich, 1999, Stanovich, 2009). A first type, system, or assembly of processes, often presented as evolutionary primitive and based on associative mechanisms, is assumed to be unconscious, fast, automatic, highly contextualized and largely independent from working memory resources and general intelligence. It would provide us with default responses and intuitions that come easily to mind, and would be responsible for the heuristic processing described by the 'heuristics and biases' literature. This first type of processing could in some circumstances be overridden by a second type. Inherently deliberative, conscious, controlled, slow, and demanding in working memory resources, this second type of processing or system is probably unique to humans and assumed to underpin analytical, logical reasoning and normative responses. This distinction between intuitive and analytical reasoning is not entirely new and echoes the distinction made by Piaget between children's thinking governed by intuitions, and later operational thinking, governed by logic, but it goes beyond this traditional conception. While Piaget assumed that intuitive thinking characterizes a developmental stage that is further integrated within higher-order structures and functioning, thus situating the two types of thinking in a developmental continuum, dual-process theories assume that the two systems are qualitatively and inherently different, still coexist in adults, and compete for controlling behavior. Thus, the main tenets of dual-process theories point towards a novel conception of cognitive development and promising new avenues of research. What are the origins of these two systems, their developmental routes, and how do they interact with each other during development? Do the two systems develop at the same rate or do they differ in the way that they are affected by developmental changes? Does analytical thinking progressively override intuitive thinking with age, as a traditional conception of cognitive development would assume, or does intuitive thinking develop and constitute itself an advanced mode of processing? More basically, does the theoretical framework provided by dual-process theories constitute an efficient and heuristic tool for conceptualizing and understanding development? These questions motivated the present special issue.

Prominent specialists in the domain of thinking and reasoning were invited to describe how the dual-process approach could account for developmental phenomena and advance our understanding of development. This question was addressed to developmental psychologists who have proposed dual-process accounts of development in the domain of thinking and reasoning, as well as to dual-process theoreticians mainly focused on adult functioning who were invited to elaborate the developmental implications of their theory. In an introductory contribution, Jonathan Evans describes the current state of the dual-process theories of reasoning and decision making in adults, and the recent extensions of his own theory by presenting a new Intervention Model. Then, Stanovich, West, and Toplak address the question of the developmental predictions that could be drawn from dual-process theories designed to account for adult cognition. These contributions are followed by the presentation of more developmentally oriented accounts. Ricco and Overton present their competence-procedural

processing model of reasoning development. Focusing on conditional reasoning, I assess the capacity of several dual-process theories to account for well-established developmental phenomena and present my own dual-process account of conditional reasoning development. Finally, Reyna and Brainerd show how their Fuzzy-Trace theory departs from dual-process theories of adult cognition in accounting for both improvement and developmental reversals in reasoning and decision making.

The dual-process theories of adult reasoning and decision making

In an introductory contribution, Jonathan Evans (2011) recalls that there are several dual-process theories, that they are not the same, and that there is no definite version. He vividly describes the evolution of the domain from theories initially based on the opposition of systems, to theories contrasting types of processing, and finally to his own recent conceptualization in terms of minds (Evans (2010)), with an old mind relying on associative forms of learning and a new mind allowing reflective and hypothetical thinking. Instead of relying on the concept of consciousness to differentiate the two ways of thinking, with an intuitive mind mainly unconscious and a conscious reflective mind, Evans suggests using the involvement of controlled attention and working memory as a criterion, with the old mind relying on associative learning and providing responses that can by-pass working memory, whereas the operations of the new mind would necessarily involve working memory. Within this general two-mind framework that encompasses a variety of functions such as learning, memory, or social cognition, Evans describes his hypothetical thinking theory for tasks involving explicit reasoning, judgment, and decision making, that is Type 2 processing. In this kind of tasks, associative processes might cue default responses than can be overridden by reflective and hypothetical thinking. Evans develops this default interventionist approach within a new Intervention Model that specifies the motivational and cognitive factors that determine the degree of effort with which Type 2 processing is engaged. Anticipating Stanovich, West and Toplak's analysis, Evans claims that there is no obvious application of dual-process theory to cognitive development because both the old and the new mind are complex and recruit a variety of systems and processes with potentially different developmental courses.

On the difficulties in drawing developmental predictions from dual-process theories

Accordingly, Stanovich, West, and Toplak (2011) warn psychologists about the difficulty of drawing developmental predictions from dual-process theories and describe the application of the dual-process approach to development as a 'deceptively complex endeavor'. They first present their dual-process account in which the intuitive heuristic system, previously called by Stanovich (1999) System 1, is now conceptualized as Type 1 processing, following Evans' (2008, 2009) suggestion. This change in terminology is motivated by the fact that far from being underpinned by a unique system, Type 1 processing is assumed to result from a heterogeneous set of systems named TASS (for The Autonomous Set of Systems). This TASS would encompass Darwinian modules responsible for most of the biases and heuristics described in the literature, but also tightly compiled knowledge bases. These knowledge bases could correspond to high-level analytical knowledge such as normative rules of rational thinking that have been over-learned through practice, as well as diagnostic cues learned inductively. As far as Type 2 processing is concerned, it would be produced by an algorithmic mind that accesses rules, procedures, and strategies that are used to override the autonomous mind. Importantly, the override of Type 1 by Type 2 processing would be initiated by a reflective mind that is itself part of Type 2 processing. This reflective mind would access general knowledge and strategies, but maybe more importantly, the person's beliefs, opinions and goals.

According to Stanovich and colleagues, this tri-partite structure and the nature of its components make it especially difficult to draw developmental predictions. They review a number of misconstrued predictions that are often drawn by developmental psychologists, such as the idea that Type 2 would progressively replace Type 1 processing with age, or that responses will become more normative with age. These difficulties lead the authors to wonder if there are situations in which developmental predictions could be clearer, but I will let the readers discover the answer. Stanovich and colleagues'

contribution ends with an expert analysis of some recent examples of these misconstruals in the developmental literature.

The distinction between competence and procedures

According to Stanovich and colleagues, the difficulty of drawing developmental predictions from dual-process theories mainly results from the possibility for Type 2 processing to migrate to the autonomous mind through automatization. This suggests that the main difference between the two types of processing relies on the degree of control that can be exerted on them rather than on some deeper difference in nature. It could even be considered that the proposal of a possible migration of processes from one Type to the other considerably weakens the opposition on which dual-process theories are based (see Reyna and Brainerd, 2011). Indeed, it might not be necessary to posit a dual mind to account for differences in the level of control exerted on cognition. For example, Osman and Stavy (2006) have suggested that intuitive rules (i.e., Type 1 processing in Stanovich's theory) and automatic rules (those rules that have migrated from the algorithmic to the autonomous mind) can be conceptualized as different points in the Dynamic Graded Continuum proposed by Cleeremans and Jiménez (2002) in which implicit, explicit and automatic types of reasoning are ordered according to their level of consciousness within a single reasoning system.

A stronger distinction is introduced between the two systems by Ricco and Overton (2011) in their competence-procedural developmental systems theory. In this theory, the heuristic systems are procedural in nature, whereas the algorithmic and reflective subsystems distinguished by Stanovich and colleagues within the Type 2 processes are competence systems. There is a clear demarcation between the two systems because the competence in this theory should not be conceived as mental representations used in actual reasoning, but as an idealization of the system of thought that reflects its organizational properties. As such, it is content free and can be understood as a natural deduction system. This echoes the notion of cognitive structure in Piaget's theory. Consequently, and following the Piagetian tradition, Ricco and Overton assume that thought is inherently logico-mathematical, providing a basis of the common assumption that System 2 or Type 2 processing delivers normative responses. The entailment logic proposed by Piaget and Garcia (1987) would be a reasonable candidate for the competence system. Thus, contrary to the modern tendency to frame all human reasoning processes in a probabilistic approach (Oaksford & Chater, 2007), Ricco and Overton claim that deduction is an important part of ordinary cognition. According to the authors, one of the interests of conceiving Type 2 processing as deductive rather than probabilistic is that a probabilistic account of Type 2 thinking blurs the distinction between the two systems and weakens the argument for dual-process theories.

The authors review developmental evidence supporting their model. In line with the predictions of the competence-procedural developmental systems theory, the frequency of normative responses in a variety of tasks involving deductive reasoning has been shown to increase from late childhood, when the competence system has reached a sufficient level of maturity to override the heuristic system. In the same way, training and content effects have been observed only when formal deductive competence is present. This theoretical framework would also account for apparent deductive competence in preschoolers and incompetence in adults. In the former case, deductive competence is erroneously attributed to the production of isolated inferences (e. g., *modus ponens*), whereas following a Piagetian conception, competence would require the integration and differentiation of the entire set of possible inferences. In the latter case, apparent incompetence in adults is accounted for by procedural obstacles that block the accessing of a nevertheless present logical competence. Interestingly, the theory makes also predictions related to cognitive aging. Because they are inherent to thinking and reflect its deep organization, deductive processes are predicted, and have been found, to be relatively immune to the effects of aging. Finally, Ricco and Overton develop their conception of a co-construction during development of the reflective and the algorithmic systems. The development of metalogical knowledge, which is an important part of the reflective system, can not be dissociated from the development of deductive competence, providing adolescents with an understanding of inference and logical necessity.

Dual-process accounts of conditional reasoning and its development

As Ricco and Overton note in their contribution, one of the domains in which the age-related increase in normative responses is the more pronounced is conditional reasoning. Conditionals occupy a privileged place in the study of reasoning and several theoretical accounts of conditional reasoning have been proposed in the last years (Barrouillet, Gauffroy, & Lecas, 2008; Evans, Over, & Handley, 2005; Johnson-Laird & Byrne, 2002). Interestingly, the development of conditional reasoning has been largely documented (see Markovits and Barrouillet (2002), for a review). In my own contribution to this special issue (Barrouillet, 2011), I take advantage of our knowledge of this development to evaluate several dual-process theories in light of the main developmental findings. I focus on three different approaches that have theorized an opposition between two systems of reasoning as a contrast between heuristic and analytical processes (Evans, 2006), between probabilistic and mental model-based reasoning (Oaksford & Chater, 2010; Verschueren & Schaeken, 2010), or that have emphasized the role of metacognitive processes in a reflective mind (Thompson, 2009, 2010). Each of these approaches has its own merits, but all present also weaknesses that prevent them from giving an exhaustive account of developmental findings. It appears that, when considering conditional reasoning, the distinction between heuristic and analytical processes drawn by Evans (2007) within his hypothetical thinking theory remains unclear. I argue that the developmental predictions that can be drawn from this theory are contradicted by facts. Though the probabilistic approach championed by Oaksford and Chater constitutes an elegant conceptualization of the Type 1 processes accessing long-term memory knowledge, one of the main limitations of the probabilistic / mental model approach is its limitation to everyday conditional reasoning. Like Ricco and Overton, I argue that any developmental approach must account for our capacity to reason from familiar situations, but also for the capacity to reason deductively from abstract premises, which is specific to humans. Oaksford and Chater (2010) suggest that this later form of reasoning would rely on the manipulation of mental models constructed by analogy with prior conditional knowledge. This proposal is problematic because Oaksford and Chater have repeatedly claimed that, contrary to formal logic, our everyday inferences are defeasible (i. e., conclusions can be lost by adding premises, Oaksford & Chater, 1998). Therefore, it is difficult to understand how logical abilities could emerge from analogies with everyday inferences that do not conform with logic. Thus, I propose a dual-process account of conditional reasoning that integrates the mental model approach within the revised heuristic / analytic model of Evans (2006) and review developmental evidence supporting this theory.

When intuitions are smarter than analytical thinking

Although Stanovich and colleagues caution developmentalists against the tendency to predict from the dual-process approach that heuristic processing necessarily decreases and that normative responding uniformly increases with age, all the dual-process theories assume that the most advanced forms of reasoning are, at least initially, a product of analytical algorithmic processing. The fuzzy-trace theory presented by Reyna and Brainerd (2011) rejects this commonly held assumption, thus refuting both Piagetian logicism and information-processing formalism. In an inspired epilogue to their article, Reyna and Brainerd note that the dualities used by Piaget between intuition and logic or by the information-processing and the dual-process theories between heuristic and analytical processes can be traced back to Descartes' dualism between the mind, the seat of reason, and the body and its "animal spirits". Instead, they propose another (in my opinion more interesting) dualism that resembles the opposition that the French philosopher and mathematician Blaise Pascal coined between two forms of mind, which he called '*esprit de finesse*' and '*esprit de géométrie*', usually translated in English by the intuitive and the mathematical minds. By '*esprit de finesse*', Pascal refers to the kind of subtle and delicate form of reasoning that can not be mathematically grasped through axioms and demonstrations, but allows us to judge at a single glance. In the same way, in fuzzy-trace theory, intuition is an advanced mode of processing, and Reyna and Brainerd claim that advanced reasoning is generally intuitive, not analytical.

As all the other dual-process theories, the fuzzy-trace theory distinguishes between analytical thinking, which is slow and conscious, and intuition that operates quickly, out of consciousness. The former way of thinking is based on verbatim representations that capture the exact surface form of the problems, whereas intuitions are based on gist representations that capture the essential meaning of the situation. Both types of thinking develop during childhood, but contrary to what dual-process theories assume, adults have a fuzzy-processing preference and favor, as a default, the simplest gist representations because gist-based intuitions increase with age and experience. Thus, the theory predicts that despite increasing competence in reasoning, some biases grow with age. Reyna and Brainerd review impressive studies in which they demonstrate for example that the framing effect described by *Tversky and Kahneman (1986)* does not decrease, but increases with age. They also show that, surprisingly, risky decisions and behaviors are more frequent when reasoning is based on the analysis of numerical representations than when based on fuzzy gist-based processing. This is why adults, who have a fuzzy-processing preference, adopt less risky behaviors than adolescents who favor quantitative thinking that leads to risk taking! One of the most fascinating applications of the theory is probably its neurodevelopmental consequences. Subjects with autism, who suffer from a deficit in gist-based intuitions, have been shown to be *less* susceptible to framing effects than controls. This thought-provoking contribution ends by the presentation of a mathematical model demonstrating that the well-known model of decision making proposed by prospect theory can be derived from fuzzy-trace theory, the power function of the prospect theory resulting from a compromise between a quantitative and linear process based on verbatim representations and a qualitative and discrete process based on gist representations.

Coda

Dual-process theories have been proposed to account for both the evolution of reasoning in children and adolescents and its end-point in adult thinking. This special issue was designed as an occasion of dialogue and exchange between two traditions of research that have too often progressed in mutual ignorance of each other. Despite the diversity of the theoretical accounts, both traditions have ended up with the same conclusion: reasoning and decision making are more complex than expected in their development, which takes a more meandering route than the smooth growth in logical thinking that the traditional developmental psychology described. I hope that the publication of this special issue will create a renewed interest in the development of thinking and reasoning and foster new avenues of research.

References

- Barrouillet, P. (2011). Dual-process theories of reasoning: The test of development. *Developmental Review*, 31(2–3), 151–179.
- Barrouillet, P., Gauffroy, C., & Lecas, J. F. (2008). Mental models and the suppositional account of conditionals. *Psychological Review*, 115(3), 760–771.
- Bjorklund, D. F. (2005). *Children's thinking: Cognitive development and individual differences*. Belmont, CA: Wadsworth Thompson Learning.
- Cleeremans, A., & Jiménez, L. (2002). Implicit learning and consciousness: A graded, dynamic perspective. In R. M. French & A. Cleeremans (Eds.), *Implicit learning and consciousness: An empirical, philosophical and computational consensus in the making* (pp. 1–40). Hove, UK: Psychology Press.
- Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologists*, 49, 709–724.
- Evans, J. St. B. T. (1989). *Bias in human reasoning: Causes and consequences*. Brighton: Erlbaum.
- Evans, J. St. B. T. (2006). The heuristic-analytic theory of reasoning: Extension and evaluation. *Psychonomic Bulletin & Review*, 13(3), 378–395.
- Evans, J. St. B. T. (2007). *Hypothetical thinking: Dual processes in reasoning and judgment*. Hove, UK: Psychology Press.
- Evans, J. St. B. T. (2008). Dual processing accounts of reasoning, judgment and social cognition. *Annual Review of Psychology*, 59, 255–278.
- Evans, J. St. B. T. (2009). How many dual-process theories do we need? One, two, or many? In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 33–54). Oxford: Oxford University Press.
- Evans, J. St. B. T. (2010). *Thinking twice: Two minds in one brain*. Oxford: Oxford University Press.
- Evans, J. St. B. T. (2011). Dual process theories of reasoning: Contemporary issues and developmental applications. *Developmental Review*, 31(2–3), 86–102.
- Evans, J. St. B. T., & Over, D. E. (1996). *Rationality and reasoning*. Hove, UK: Psychology Press.
- Evans, J. St. B. T., Over, D. E., & Handley, S. J. (2005). Suppositions, extensionality and conditionals: A critique of the mental model theory of Johnson-Laird and Byrne (2002). *Psychological Review*, 112, 1040–1052.

- Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York: Basic Books.
- Johnson-Laird, P. N., & Byrne, R. M. J. (2002). Conditionals: A theory of meaning, pragmatics, and inference. *Psychological Review*, 109, 646–678.
- Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristic and biases*. Cambridge, UK: Cambridge University Press.
- Manktelow, K. (1999). *Reasoning and thinking*. Hove, UK: Psychology Press.
- Markovits, H., & Barrouillet, P. (2002). The development of conditional reasoning: A mental model account. *Developmental Review*, 22(1), 5–36.
- Morra, S., Gobbo, C., Marini, Z., & Sheese, R. (2008). *Cognitive development: Neo-piagetian perspectives*. New York NY: Lawrence Erlbaum.
- Oaksford, M., & Chater, N. (1998). *Rationality in an uncertain world*. Hove, UK: Psychology Press.
- Oaksford, M., & Chater, N. (2007). *Bayesian rationality: The probabilistic approach to human reasoning*. Oxford, UK: Oxford University Press.
- Oaksford, M., & Chater, N. (2010). Conditional inference and constraint satisfaction: Reconciling mental models and the probabilistic approach. In M. Oaksford & N. Chater (Eds.), *Cognition and conditionals: Probability and logic in human thinking* (pp. 309–334). Oxford: Oxford University Press.
- Osman, M., & Stavy, R. (2006). Development of intuitive rules: Evaluating the application of the dual-system framework to understanding children's intuitive reasoning. *Psychonomic Bulletin and Review*, 13(6), 935–953.
- Piaget, J., & Garcia, R. (1987). *Vers une logique des significations*. Genève: Muriende.
- Reyna, V. F., & Brainerd, C. J. (2011). Dual processes in decision making and developmental neuroscience: A fuzzy-trace model. *Developmental Review*, 31(2–3), 180–206.
- Ricco, R. B., & Overton, W. F. (2011). Dual systems competence-procedural processing: A relational developmental systems approach to reasoning. *Developmental review*, 31(2–3), 119–150.
- Solman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, 119, 3–22.
- Stanovich, K. E. (1999). *Who is rational? Studies of individual differences in reasoning*. Mahwah, NJ: Lawrence Erlbaum.
- Stanovich, K. E. (2009). Distinguishing the reflective, algorithmic, and autonomous minds: Is it time for a tri-process theory? In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 55–88). Oxford: Oxford University Press.
- Stanovich, K., West, R. F., & Toplak, M. E. (2011). The complexity of developmental predictions from dual process models. *Developmental Review*, 31(2–3), 103–118.
- Thompson, V. A. (2009). Dual-process theories: A metacognitive perspective. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 171–198). Oxford: Oxford University Press.
- Thompson, V. A. (2010). Towards a metacognitive dual process theory of conditional reasoning. In M. Oaksford & N. Chater (Eds.), *Cognition and conditionals: Probability and logic in human thinking* (pp. 335–354). Oxford: Oxford University Press.
- Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of Business*, 59(4), 251–278.
- Verschueren, N., & Schaeken, W. (2010). A multi-layered dual-process approach to conditional reasoning. In M. Oaksford & N. Chater (Eds.), *Cognition and conditionals: Probability and logic in human thinking* (pp. 355–370). Oxford: Oxford University Press.
- Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology*, 12, 129–140.
- Wason, P. C. (1966). Reasoning. In B. Foss (Ed.), *New horizons in psychology* (Vol. 1). Harmondsworth, UK: Penguin.