

CURRENT DIRECTIONS IN IMPLICIT LEARNING: WHERE IS IT THAT WE WERE SUPPOSED TO GO AGAIN?

Axel CLEEREMANS and Alain CONTENT
Université Libre de Bruxelles

Implicit learning has become such a hot topic that papers that start by saying so are now commonplace. How come? One of the reasons is probably that implicit learning, or the process by which we learn without intention to learn and without awareness of the resulting knowledge, is a ubiquitous phenomenon. Several different fields can therefore claim to have something to say about it. Hence over the past decade or so, we have witnessed the emergence of increasingly strong connections between the field of implicit learning as such (see Berry & Dienes, 1993; Reber, 1993, for introductions) and fields such as cognitive development (e.g., Karmiloff-Smith, 1992), language (e.g., Ellis, 1994), computational modeling (e.g., Cleeremans, 1993), memory (see Berry & Dienes, 1993; Neal & Hesketh, 1997; for discussions), concepts and categorization (e.g., Ashby, Alfonso-Reese, & Turken, in press; Brooks, 1978), social cognition (e.g., Lewicki, 1986), neuropsychology (e.g., Knowlton, Ramus, & Squire, 1992) and, not surprisingly, consciousness (e.g., Chalmers, 1996; Searle, 1992). The latter is perhaps the most significant field, in that the consideration of consciousness as a scientific object of investigation, and as a philosophical object of debate, is perhaps what has been missing most in implicit learning research. The field has indeed been characterized (and still is today, to a large extent) by a distinct lack of theoretical development. The problem, to put it bluntly, is simply that no one really knows what consciousness is all about. Claims that one can learn and do things without it are therefore necessarily bound to be controversial and marred with methodological debate. Thus, research about implicit learning appears to be inextricably tied to research about consciousness, and advances in our understanding of the former will tend to remain out of reach until the latter is somehow addressed. But understanding consciousness in turn requires us to understand the basic

Axel Cleeremans, Laboratoire de Psychologie Industrielle et Commerciale & Séminaire de Recherche en Sciences Cognitives; Alain Content, Laboratoire de Psychologie Expérimentale & Séminaire de Recherche en Sciences Cognitives.

This work benefited from funding by FRFC Grant # 9.4565.92 to Axel Cleeremans and Alain Content. Axel Cleeremans is a Research Associate of the National Fund for Scientific Research (Belgium).

Correspondence concerning this article should be addressed to Axel Cleeremans, Séminaire de Recherche en Sciences Cognitives, Université Libre de Bruxelles CP 122, Avenue F.-D. Roosevelt 50, 1050 Bruxelles. Electronic mail may be sent to either axcleer@ulb.ac.be or to acontent@ulb.ac.be.

properties of the human cognitive system that make it possible for consciousness to emerge and for learning to occur without it. Can this vicious circle be broken somehow?

A positive answer to this question is, by and large, the basis of the perspective adopted by Luis Jiménez in the article that opens this special issue. Jiménez tackles the difficult issue of determining what the best empirical approach to implicit learning may be in the absence of any clear conceptual or operational definition of awareness. Surprisingly perhaps, his conclusions are rather optimistic. First, Jiménez suggests that research about implicit learning should be predicated on the formulation of simple assumptions about the relationship between performance and awareness. Next, he shows how once such assumptions have been agreed upon, one can then move ahead and define empirical strategies that make it possible to demonstrate the existence of unconscious knowledge. Jiménez also points out that the kind of evidence typically taken as indicative of the existence of implicit learning may in fact often turn out to describe other phenomena, and that the many current different definitions of implicit learning reflect the diversity of the experimental paradigms used in the field. One important relevant conceptual distinction is whether the qualification of implicitness applies to the learning process, to the results of learning, or to both.

In the second part of the paper, Jiménez proposes that instead of searching for the Graal of pure measures of conscious and unconscious knowledge, a more productive strategy (inspired from research in implicit memory and implicit perception) might consist of comparing the sensitivity of direct and indirect measures of performance involving the relevant information. He illustrates this proposal with a recent study using a serial reaction time task in which significant residual correlations between stimulus sequences characteristics and RTs remained after performance in a generation task had been partialled out.

Jiménez's conceptual analysis is also an opportunity to describe the main issues that face the field, and thus serves as a useful introduction to the more empirically-oriented papers that together constitute the rest of this special issue. These contributions vividly illustrate how the issue of implicit learning can be explored in sometimes very different empirical contexts, and together, they offer a perspective on implicit learning that spans not only the three most popular paradigms in the field (sequence learning, artificial grammar learning, and process control) but also more unusual paradigms, such as evaluative learning, hidden covariation detection, or probability matching. In the following, we briefly introduce each contribution.

Hilde Hendrickx and Jan De Houwer report on their work with one of the earliest paradigms through which implicit learning has been investigated: Lewicki's hidden covariation detection task (e.g., Lewicki, 1986). In such

tasks, participants are exposed to stimuli that contain very subtle covariations between unattended features. Do participants automatically learn something about these "hidden" covariations? What are the limits of implicit learning? Hendrickx and De Houwer's conclusions are somewhat pessimistic in that, despite numerous attempts (see Hendrickx, De Houwer, Baeyens, Eelen & Van Avermaet, 1997), they failed to replicate the original studies. Several successful closely related paradigms are also described however, which provides the authors with an opportunity to discuss the conditions under which one might expect to find evidence for implicit learning. These conditions, according to the authors, are related to the extent with which acquired representations have to be transformed so that they can determine performance in a way that complies with the task demands. Thus, one is more likely to observe implicit learning when the task instructions are such that simple associative knowledge can be expressed directly in performance. Hendrickx and De Houwer then use this process-oriented analysis to draw an interesting parallel between implicit learning and conditioning, and briefly report on experimental work meant to address this correspondence directly.

In his contribution, Pierre-Jean Marescaux also tackles the difficult methodological issues of how explicit/conscious knowledge can be assessed, but in a very different manner. He discusses the pros and cons of objective tests of awareness based on direct measures of knowledge, and the potential value of subjective tests, in which participants are required to assess their own knowledge in addition to responding to the direct test. In this context, Marescaux argues that free verbal reports have not generally been analyzed properly, and that their value has therefore been underestimated. The difficulty of analyzing verbal reports can be overcome by using Mathews et al. (1989)'s *yoked subjects* technique, by which the information contained in the verbal reports of trained subjects can be assessed by the effect they have on naive subjects. If the reports can be shown to help naive subjects perform better than uninformed subjects, then undoubtedly one has to conclude that they contained task-relevant verbalizable knowledge. Marescaux then reports on some of his current empirical research in this framework, using Berry and Broadbent (1984)'s sugar factory paradigm — perhaps the prototypical example of the so-called dynamic control tasks which prompted renewed interest in implicit learning in the early 1980s. The most striking outcome of Marescaux's research is that the performance of untrained, novice subjects who merely had an interview with a previously trained subject before actually performing the experiment was indistinguishable from that of the trained subjects, suggesting that any knowledge available in the task was also available for later verbal report. Such results prompt Marescaux to conclude that strong dissociations between implicit and explicit knowledge need to be reassessed. Marescaux also points out, however, in a way that illustrates the definitional issues that the field is currently facing,

that it is not the implicit character of learning that is put into question by his results, but rather the unavailability of the resulting knowledge. Presumably, the specific task that participants are exposed to is also crucially important in determining to what extent knowledge is explicit or implicit: Process control tasks, for instance, are likely to induce participants to adopt hypothesis-testing strategies, which is presumably not the case for tasks such as sequential reaction time tasks.

Thierry Meulemans and Martial Van der Linden review in some detail the artificial grammar learning paradigm, which was initially explored by Reber in 1967 (Reber, 1967) and which is therefore generally viewed as the core paradigm through which implicit learning has been explored. Their discussion illustrates the increasing sophistication of this line of investigation. One fundamental issue about implicit learning concerns the nature of the acquired knowledge. Is it best characterized as abstract, thus as reflecting somehow the deep structural features of the stimulus material, or as exemplar-based, that is, as based on the surface similarity relationships between exemplars? In the context of artificial grammar learning research, this question has generally been framed as a contrast between the hypothesis that subjects induce abstract rules similar to the grammar used to generate the stimuli, and the notion that subjects remember fragments of the strings to which they have been exposed. Meulemans and Vanderlinden show how the difficult issue of separating possible contributions from abstract knowledge and from memory for exemplars can be explored by contrasting grammaticality and familiarity. Their results lead to a complex, but sensible picture: Either factor can be shown to influence classification performance, as a function of the size of the training set. When the training set is relatively limited in size, chunk familiarity dominates, whereas grammaticality plays a prominent role when subjects are exposed to a larger set during the training phase of the experiment.

Another issue addressed by Meulemans and Van der Linden is that subjects might learn some features of the material during the test phase itself. One obvious remedy to this artefact is to compare the classification performance of subjects exposed to grammatical strings to an untrained group of control subjects. Indeed, Meulemans and Van der Linden report that in some of their experiments control subjects could classify strings better than chance, presumably thanks to sensitivity to subtle differences in digram and trigram frequencies between grammatical and ungrammatical stimuli.

Zoltán Dienes, Andreas Kurz, Regina Bernhaupt and Josef Perner also explore performance in the artificial grammar learning paradigm. They ask the following simple question: Once you have some (often imperfect) knowledge, how do you use it to make decisions? Do you choose among your possible responses probabilistically, as a function of how well your knowledge matches the stimulus, or do you only apply your knowledge when it matches the

stimulus almost perfectly, guessing randomly otherwise? Dienes et al. describe how these two strategies correspond to different models of implicit learning, and test these theories directly in three experiments involving artificial grammar learning. As is often the case in implicit learning research, their results are not clear-cut. They nevertheless vividly illustrate how the interplay between the formulation of theoretical predictions and empirical data often result in clear recommendations for further research. Most importantly, their contribution may also remind us that a full understanding of the processes involved in typical implicit learning tasks also requires to get a handle on how the available knowledge is used by participants in making the required volitional decisions.

Jan De Houwer, Frank Baeyens and Hilde Hendrickx introduce us to the paradigm of evaluative learning—the process by which previously neutral affective stimuli are evaluated differently after they have become associated with affectively loaded stimuli. Can evaluative learning proceed implicitly? The authors provide evidence that indeed, such learning can take place without awareness. This paradigm, according to the authors, has several properties that make it less susceptible to methodological criticism than the paradigms through which implicit learning has typically been explored. In particular, De Houwer et al. specifically discuss how their paradigm can be seen as addressing Shanks and St. John (1988)'s *information* and *sensitivity* criteria, and further explore the notion that implicit evaluative learning can perhaps be taken as a form of classical conditioning.

Finally, Michaël Dubois and Guy Lories suggest one further extension to the already large experimental repertoire of the field, thus providing an additional demonstration of the ubiquity of implicit learning. Their starting point is human performance in the prediction of statistical series, in a paradigm similar to or reminiscent of the probability matching paradigm used by Reber and colleagues in their early studies (see Reber, 1989, for a review). Dubois and Lories's experiment examines how subjects learn to classify continuous sequences into two categories in the absence of any feedback, and to what extent the learning transferred to new sequences. Unfortunately, although the authors discuss the analogy between their experimental paradigm and Reber's artificial grammar situation, no direct evidence is provided about the conscious or unconscious nature of the acquired knowledge. This, presumably, is a matter for future research.

The seven articles included in this special issue were written at our request based on the participation of their authors to a workshop held in Brussels on May 22nd, 1995. We believe that this special issue of *Psychologica Belgica* constitutes an interesting and particularly varied depiction of the current state of a broad and increasingly important field in cognitive science. Most of the central questions that the field is currently debating about are represented in the different contributions: The nature of implicit knowledge, the processes

involved in implicit learning, the role of conscious awareness, and the difficult methodological issues involved in assessing explicit knowledge.

It would have been nice if the different contributions had converged on clear and uncontroversial definitions of concepts such as implicit learning, awareness, consciousness and the like... but such a goal was clearly overambitious for a one-day meeting! The present contributions instead offer a kaleidoscopic view of the field by illustrating how diverse various approaches to implicit learning can be, in terms of paradigms, methods, and conceptual frameworks. This diversity may appear somewhat distressing, in a way reminiscent of when you drive around for so long in an unknown city that you end up losing track of where it was that you were supposed to go in the first place. But this diversity is characteristic of implicit learning research, and we believe it is a direct result of the fact that implicit learning as such does not designate a single, neatly defined process, but rather fundamental adaptative mechanisms that pervade our entire cognitive system. There are thus many different ways in which some knowledge can be implicit, and many different degrees to which it can be accessible to conscious inspection. Different tasks place different demands on participants, and are thus more or less likely to make it mandatory that some knowledge is used intentionally. The articles of this special issue make this ubiquitous character of implicit learning very salient — a good thing for the field as a whole.

In closing, we would like to thank the National Fund for Scientific Research for providing us with the funding necessary to invite foreign participants. The workshop was held as part of the "Groupes de Contact du F.N.R.S.: Etude des processus cognitifs" series. This series of workshop was then under the presidency of Serge Brédart, and we would like to take this opportunity to thank him for giving us the chance to organize this meeting.

References

- Ashby, F.G., Alfonso-Reese, L.A., & Turken, A.E. (1996). *A formal neuropsychological theory of multiple systems in category learning*. Unpublished manuscript.
- Berry, D.C., & Broadbent, D.E. (1984). On the relationship between task performance and associated verbalizable knowledge. *Quarterly Journal of Experimental Psychology*, 36a, 209-231.
- Berry, D.C., & Dienes, Z. (1993). *Implicit learning: Theoretical and empirical issues*. Hove, UK: Erlbaum.
- Brooks, L.R. (1978). Nonanalytic concept formation and memory for instances. In E. Rosch & B.B. Lloyd (Eds.), *Cognition and categorization*. New York: Wiley.
- Cleeremans, A. (1993). *Mechanisms of implicit learning: Connectionist models of sequence processing*. Cambridge, MA: MIT Press.
- Chalmers, D.J. (1996). *The conscious mind: In search of a fundamental theory*. Oxford: Oxford University Press.

- Ellis, N. C. (1994). *Implicit and explicit learning of languages*. London: Academic Press.
- Frensch (in press). Same concept, multiple meanings: On how to define the concept of implicit learning. In M. Stadler & P. Frensch (Eds.), *Handbook of implicit learning*. Thousand Oaks, CA: Sage.
- Hendrickx, H., De Houwer, J., Baeyens, F., Eelen, P., & Van Avermaet, E. (1997). Hidden covariation detection might be very hidden indeed. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23, 201-220.
- Karmiloff-Smith, A. (1992). *Beyond modularity*. Cambridge, MA: MIT Press.
- Knowlton, B.J., Ramus, S.J., & Squire, L.R. (1992). Intact artificial grammar learning in amnesia: Dissociation of classification learning and explicit memory for specific instances. *Psychological Science*, 3, 172-179.
- Lewicki, P. (1986). *Nonconscious social information processing*. New York: Academic Press.
- Mathews, R.C., Buss, R.R., Stanley, W.B., Blanchard-Fields, F., Cho, J., & Druhan, B. (1989). The role of implicit and explicit processes in learning from examples: A synergistic effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 1083-1100.
- Neal, A., & Hesketh, B. (1997). Episodic knowledge and implicit learning. *Psychonomic Bulletin and Review*, 4, 24-37.
- Reber, A.S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior*, 6, 855-863.
- Reber, A.S. (1993). *Implicit learning and tacit knowledge*. Oxford: Oxford University Press.
- Schacter, D.L., Bowers, J., & Booker, J. (1989). Intention, awareness and implicit memory: The retrieval intentionality criterion. In S. Lewandowsky, J.C. Dunn, & F. Kirsner (Eds.), *Implicit memory: Theoretical issues*. Hillsdale, NJ: Erlbaum.
- Searle, J.R. (1992). *The rediscovery of the mind*. Cambridge, MA: MIT Press.
- Shanks, D.R., & St John, M.F. (1994). Characteristics of dissociable learning systems. *Behavioral and Brain Sciences*, 17, 367-395.