Section IV

Mechanisms of cognitive control

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Chapter 18

On unconscious inhibition: Instantiating repression in the brain

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Abstract

In psychodynamic theory, repression is a major neurotic defence mechanism, which operates by separating the drive investment from the conflictual representation. While major insights in unconscious processing have recently been obtained in the cognitive neurosciences, repression as a psychological mechanism remains controversial. In this chapter, we present empirical results obtained with subliminal priming paradigms concerning unconscious inhibition of (1) mental representations and (2) motor control. For these paradigms, we propose that only under very stringent subliminal conditions where stimuli are completely undetectable, the dynamics of deep unconscious processing—which are structurally sensitive to subject factors such as defensivity and anxiety—are discernable. We also present parallel results of (3) suppression and inhibition in memory and language processing. A similar observation in these various results is that inhibition reveals itself by spilling over to associated elements which were not its original targets. Finally, we propose a speculative model on the physiology of repression. First, we present a series of arguments indicating a conceptual closeness between the 'indications of reality' in the Freudian model and the efference copies of the sensorimotor models. Moreover, a number of other parallels between the psychodynamic and the sensorimotor approach have been uncovered in recent neurosciences, chief among which is the constitutive link between representation and action: thinking is only possible as a motor activity and this thinking is not a priori conscious. Afferent stimuli probe for a multiplicity of associated action plans: directed action, then, is only possible by selecting one alternative through inhibition of the others. This inhibition might function through the anticipative attenuation brought about by the efference copies. The efference copy-induced somatosensory activations linked to motor control are thought to induce mental imagery in response to incomplete action execution. This, then, would be especially the case for some of these action alternatives, which are easily susceptible of popping up due to their emotional importance. In order to act appropriately, these frequent candidates require a more vigorous inhibition, which would then be particularly prone to induce (unconscious) mental imagery as well as to spill over to associated representations and induce substitutive behaviours, which, together, would constitute 'the return of the repressed'.

Keywords: repression; inhibition; unconscious; subliminal; sensorimotor.

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Introduction

The concept of the 'dynamic unconscious' is a major bedrock of psychoanalytic theory. This unconscious (see Box 18.1) is said to be dynamic because it results from the dynamic process of repression. While major insights in unconscious processing have been obtained these past 10 years in cognitive neurosciences, the possibility of repression as a psychological mechanism remains controversial. However, Freud himself qualifies repression as 'the corner-stone on which the whole structure of psychoanalysis rests' (1914, p. 16). In this chapter, we briefly spell out the metapsychology of repression in Freudian theory, we overview experimental results on unconscious processing in the areas of defence and inhibition, and we present some tentative ways to understand repression in physiological terms.

Box 18.1 Term definitions

The adjective '*unconscious*': This term refers to those contents that are not present in consciousness and more broadly, to those features of mental life of which people are not subjectively aware. Here unconscious is used in a descriptive way and not in a topographical way. In Freud's first topography (1900) of the mental apparatus the following distinctions are made: that which is present in our minds is conscious; that which is not present but retrievable in memory is preconscious; that which is not retrievable by conscious will is unconscious. Hence, the 'descriptive unconscious' does not discriminate between, for example, preconscious and unconscious contents. (further reading see Freud, 1912, 1915b; Laplanche and Pontalis, 1974; Person et al., 2005).

Dynamic unconscious: This term is a more specific construct and refers to mental contents that are defensively removed from consciousness as a result of repression. The dynamic unconscious is not unconscious because there is no conscious will to retrieve it, but because there is an active blockade of the access to consciousness. The term reflects the idea that psychical life is in conflict, this is the dynamic point of view; this conflict can be considered in very general terms as an intrapsychic conflict between the drives (the biological level) and the internalized social constraints (the social level). (further reading see de Mijolla, 2005; Freud, 1915a,b;; Laplanche and Pontalis, 1974; Person et al., 2005).

System unconscious (Ucs.): This term denotes the idea of a system of unconscious contents, organized by principles different from those of the conscious mind. The Ucs. includes both 'wishful impulses' derived from the drives, and the repressed materials. This system is cathected (or invested) by free-flowing energy (called 'libido' or drive energy), operates along the logic of primary process thinking, such as condensation and displacement, and is governed by the pleasure principle. The Ucs. is left rather vague, but later on Freud uses this to describe his second topography (1923), his tripartite model of the mind as id, ego, and superego, where the id incorporates the Ucs. and inherits its characteristics, while the assets of the adjective 'unconscious' accrue from the id and to a large extent from the ego. (further reading see de Mijolla, 2005; Freud, 1900, 1923; Laplanche and Pontalis, 1974; Person et al., 2005).

Defence mechanisms: These are psychic transformation processes which organize and maintain optimal psychic conditions by attempting to keep anxiety levels as low as possible in response to experiences that generate conflict in general and, more specifically, in response to experiences that are painful, intolerable, or unacceptable. Defence then is a general designation for diverse specific mental mechanisms deployed in response to conflict including repression, introjection (or identification), projection, denial, forclusion, sublimation, reaction-formation, isolation. (further reading see de Mijolla, 2005; Laplanche and Pontalis, 1974; Person et al., 2005).

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Box 18.1 Term definitions (continued)

Repression: This is a specific form of defence. Initially described in conjunction with hysteria, repression plays a major role in neurosis in general, including in normal psychic activity. It can be considered a universal psychic process insofar as it is constitutive of the dynamic unconscious. Repression operates by blocking action upon a representation which generates conflict. The associated affective or drive investment—this is the quantitative or energetic factor—is separated from the representation and both have different fates in the psyche. In hysteria, the quantum (re-)invests the body, causing conversion symptoms, in obsessional neurosis, it is attached to other, seemingly unconnected ideas, causing them to become obsessional. Thus the neurotic symptoms constitute the 'return of the repressed'. The representations, having lost their investments, are now unconscious and are said to be repressed. (further reading see de Mijolla, 2005~~;; Laplanche and Pontalis, 1974; Person et al., 2005~~)

Inhibition: This term in general, refers to blockage of action: indeed, actions can be initiated and then cancelled; this is the 'physical-response' concept of inhibition. In the present text, the term is not in the first place used in its psychodynamic sense as the constraint or curtailment of impulses or desires. Rather, it is used as referring to its diverse neuroscientific meanings as the opposite of facilitation or excitation; eventually it refers to the reduction of activity as the result of an antagonistic stimulation state created at synapses making them less excitable by other sources of stimulation. The important characteristic feature for inhibition, then, is its dimension of 'subtraction' or 'negative effect': at the level of the synapses this is realized by hyperpolarization, while activation or excitation involves depolarization.

~~References and further reading see de Mijolla, 2005; Eagle, 2000a,b; Freud, 1900, 1912, 1915a,b, 1923; Kandel et al., 1991; Laplanche and Pontalis, 1974; Le Guen, 1992; Le Guen et al., 1986; Logan and Cowan, 1984; Person et al., 2005.~~

Metapsychology of Freudian repression

In his metapsychological article 'The unconscious', Freud proposes: 'The nucleus of the *Ucs.* [the system unconscious] consists of instinctual [drive] representatives—*Vorstellungsrepräsentanzen*—~~of the drive~~ which seek to discharge their cathexis; that is to say, it consists of wishful impulses' (1915b, p. 186). Sources of the drives are the states of need of the inner body, such as tissue dehydration. While the drive might still be conceived of as a tension of the inner body, the *Vorstellungsrepräsentanz* or *representance*[1] is the first real mental breakthrough. To this representance, a content value in response to the need can be ascribed. For example, the content might be 'thirst' or 'wanting to drink'. It is then this content which gets represented. For example, the content of 'thirst' might get represented by the baby with a cry *if* his mother was able to interpret the cry more or less satisfyingly by feeding the baby (see Figure 18.1). In this case the baby's cry becomes an adequate act. Or it might get represented by the idea of taking a glass of water or by the question addressed to someone asking for a drink, etc. These representations are then concrete action plans adapted to the subject, his actual state, and the context. In other words, while the representance strives for an alleviation of thirst, responding in content to the drive arising from the inner

[1] Freud writes *Repräsentanz*, which is translated as 'representative' but of which the translator and editor Strachey says that 'it would be better rendered by 'representance' if it existed . . .' (Strachey, 1957, p. 112). In French this term is often translated as 'représentance' (see e.g. Roussillon, 2007). To remain close to Freud's choice for the word *Repräsentanz* and to avoid confusion between *Repräsentanz* and *Repräsentant* (which is also translated as 'representative'), we have chosen to use the form 'representance'.

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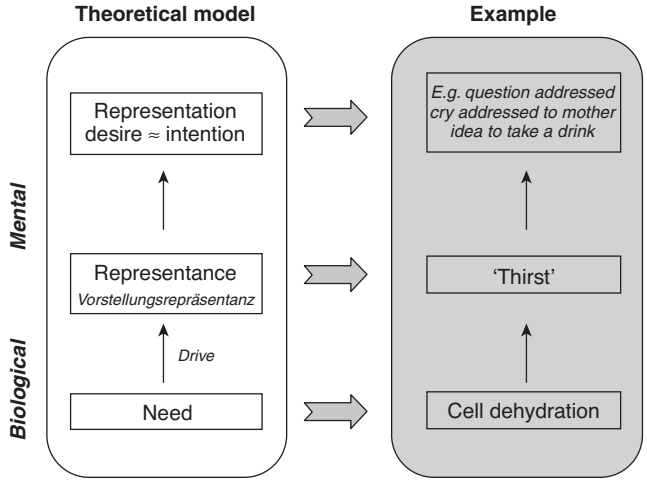

Fig. 18.1 Logical distinctions between drive and representation (action plan) and the shift from biological to mental.

body, the concrete representations of the representance strive for a new external body configuration, such as the right position of the head towards the breast, or the grasp position of the arm, etc. Freud's *dynamic* unconscious (see also Northoff (Chapter 15) and Solms and Zellner (Chapter 12), this volume) is said to be dynamic because it results from repression; this repression can be considered as the consequence of a conflict between the drives on the one hand and the social constraints on the other (i.e. the mental level arises from tension between the biological and the social level). The drive in itself can not be repressed, only the 'wishful impulses' can. This repression implies that the representations of the representance are prevented from being executed or spoken. Freud says: 'A presentation which is not put into words, or a psychical act which is not hypercathected, remains thereafter in the Ucs.' (1915b, p. 186). Without these representations, the subject loses the means to become aware of this drive: this content then remains unconscious. But Freud adds: 'it is a mistake to emphasize only the repulsion which operates from the direction of the conscious upon what is to be repressed. Quite as important is the attraction exercised by what was primarily repressed upon everything with which it can establish a connection'. Indeed: 'repression does not hinder the drive representative from continuing to exist in the unconscious, from organizing itself further, putting out derivatives and establishing connections' (1915a, p. 149). In other words, the withdrawal of cathexis at the level of certain representations implies the over-investment of associated substitutive representations: 'If these derivatives have become sufficiently far removed from the repressed representative, whether owing to the adoption of distortions or by reason of the number of intermediate links inserted, they have free access to the conscious' (Freud, 1915b, p. 149).[2] This over-investment of substitutive representations is called 'the return of the repressed'

[2] One way in which derivatives can be at the same time connected to and far removed from the original wishful impulse, is by deviating mental investment into word representations with a similar form but a radically different meaning: 'The ideas which transfer their intensities to each other stand in the loosest mutual relations. They are linked by associations of a kind that is scorned by our normal thinking and relegated to the use of jokes. In particular, we find associations based on homonyms and verbal similarities treated as equal in value to the rest' (Freud, 1900, p. 596; for an account of a possible physiological interpretation of this mechanism, see Bazan, 2007a, in press).

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(Freud, 1915a, p. 154). But action upon these substitutes is unable to alleviate the drive tensions of the inner body, which will keep on insisting, while the subject has no means to become knowledgeable of what moves him. This is a brief outline of the dynamic principles of Freudian repression.[3]

~~A state of need of the internal body (e.g. cellular dehydration) yields an insisting and peremptory excitation corresponding to a drive. The first breakthrough of this drive at the mental level, then, is the 'representance', to which a content value in response to the need can be ascribed (e.g. 'thirst'). It is then this content which is translat[illegible]o concrete actions plans of the external body, which are response alternatives to the internal state of need (e.g. to ask for or to take a glass of water). If these actions are effective in alleviating the original state of need, they become *adequate acts*. These action plans or intentions (or desires), derived from the drive, correspond with representations at the mental level (see Jeannerod, 1994).~~

Empirical results pertaining to the issue of repression

Unconscious inhibition of mental representations

A methodology to study unconscious mental processes

Contrary to what was assumed in cognitive neuroscience, unconscious processing research by *subliminal priming* (Dehaene et al., 1998; Greenwald et al., 1996) was able to show that unconscious processes are not limited to automatic or 'dumb' operations (e.g. Greenwald, 1992; Loftus and Klinger, 1992). The *priming* paradigm presents a first stimulus, the prime, and measures its influence on a second stimulus, the target (Segal and Cofer, 1960). When the prime is shown below a certain threshold—or *limen*—related to consciousness, the priming is said to be *subliminal*. The subliminal threshold for visual stimuli is obtained by reducing the presentation time. A tachistoscope (see Figure 18.2) is a mechanical device that allows reducing presentation times to a thousandth of a second or less (see below section on 'Robust inhibition results as a function of individual differences'). Even at these low presentation times, the stimulus tends to persist in the participant's visual iconic memory for a time after it has physically disappeared (Sperling, 1960) and it may therefore attain conscious awareness. To overwrite this visual buffer, so that the effective presentation duration is the same as its actual duration, a *mask* is used. In tachistoscopic procedures, at very low presentation times, an energy mask is often sufficient: this energy mask then simply consists of a blank field that is either brighter than the previous subliminal field or is on for a longer period of time, thus resulting in a greater amount of light energy hitting the eye.

However, due their refresh rates, presentation times on computer screens cannot be reduced as much and hence, a pattern mask containing similar features as the prime is presented, overwriting the prime on the display (Turvey, 1973; Marcel, 1983). Primes can also be embedded in sandwich masking, a rapid sequential presentation in which the prime is preceded and followed by a mask. Prime duration for subliminal priming in these kinds of set-ups typically varies between 20 and 50 ms. Subliminal perception is inferred when a stimulus is demonstrated to be invisible while still influencing thoughts, feelings, actions, learning, or memory. In other words, to demonstrate unconscious influences the *dissociation paradigm* (Erdelyi, 1985, 1986) is used, which compares performance on two tasks, a direct discrimination task (e.g. detection) or *conscious perception index* (CPI) and an indirect task requiring more complex processing (e.g. semantic priming) or *unconscious perception index* (UPI). The dissociation paradigm shows unconscious processing if

[3] For a more thorough and complete overview on repression we refer to Freud (1915a,b), Le Guen (1992), Le Guen et al. (1986), and Eagle (2000a,b).

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Fig. 18.2 A participant looking through a tachistoscope (three-channel Gebrandt T-scope) in the Shevrin lab (7 April 2009). The cards carrying the visual stimuli are individually lighted by neon light tubes at the side. Time and sequencing are monitored by a computer.
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positive effects are obtained on the UPI despite null sensitivity on the CPI. Concretely, if, for example, semantic effects are obtained despite demonstrable absence of detection, then these semantic effects are shown to be unconscious.

Subliminal priming shows high-level unconscious mental operations

Subliminal perception research has a long-standing history of more than a century, an excellent review of which has been published by Kouider and Dehaene (2007). This history has repeatedly been dominated by methodological debates. In 1960, Eriksen proposed that the subjective (introspective) measures of conscious perception were unreliable and he replaced them by an objective index defined as a situation where *forced-choice discrimination* is at chance. Instead of asking participants to subjectively report a direct measure (e.g. to identify the stimulus), they are put before a forced choice, obliging them to respond to the best of their abilities even if they feel unsure. If these forced choice responses have no correlation with the actual presentations, null sensitivity on the direct CPI task is established (see also section on 'Robust inhibition results as a function of individual differences'). An indirect UPI measure is subsequently used to show that, nevertheless, this stimulus still influences behaviour. In 1986, Holender published an intensively argued criticism of masked priming in which he stated that the issue of awareness was still largely underestimated and in which he stressed the need to carefully control the methods. Moreover, with the advent of signal detection theory (SDT),[4] Merikle (1982) argued that the small sample of items frequently used to evaluate the threshold for conscious perception was not statistically reliable.

[4] Signal detection theory (SDT; e.g. Green and Swets, 1966) is a mathematical theory that enables to quantify the ability to discern between signal and noise. It characterizes not only the acuity of an individual's discrimination but it also suggests that individuals are actively involved in the response so that it depends not only on the subject's ability to discriminate between the signal and noise, but also on the subject's response bias or response criterion.

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Thanks to these studies, new and stronger paradigms of subliminal priming emerged with important methodological improvements leading to subliminal priming studies showing high-level mental processes. In the study of Dehaene and colleagues (1998), subjects classified numbers as smaller or larger than the reference number 5. These numbers were preceded by subliminal number primes that are also smaller or larger than 5; subjects were faster when both the prime and the target belong to the same category. Dell'Acqua and Grainger (1999) asked participants to categorize pictures of objects as referring to living things or artefacts; a prime-target congruity effect is found, which cannot be explained by methodological artefacts or alternative hypotheses and which therefore demonstrates a genuine subliminal lexical, if not semantic, effect. Moreover, using 'event-related potentials' (ERPs) as a brain measure, Kiefer and Brendel (2006) indicated that subliminal priming is reflected in the N400 component, which is an ERP component indicative of either lexical or semantic integration of information. Dehaene and colleagues (2001) and Devlin and colleagues (2004) showed that the left occipitotemporal region is sensitive to repetition priming from masked words, independently of the case in which words are presented, and with a sensitivity to orthographic similarity. The left middle temporal gyrus is sensitive to priming by synonym words (Devlin et al., 2004) as well as priming by repetition of words presented in the Kanji and Kana Japanese writing systems (Nakamura et al. 2005), suggesting that this region encodes words at a semantic level. For numbers, Naccache and Dehaene (2001) observed a brain imagery effect in bilateral intraparietal cortices, at a site thought to encode numerical magnitudes, thereby suggestive of true semantic activation by the subliminal primes. Naccache et al. (2005) also found that masked words that are threatening increase the activity in the amygdala compared with neutral words, while subjects are totally at chance in categorizing these masked words as threatening or neutral. In conclusion, a body of evidence has accumulated in the domain of subliminal priming showing the existence of high-level perceptual, arithmetic, lexical, affective, and possibly semantic processes (see also Kouider and Dehaene, 2007).

Subliminal priming research at the subjective detection threshold: the impossibility of unconscious inhibition of mental representations?

However, these findings do not demonstrate the Freudian unconscious of psychoanalysis, which is first and foremost a *dynamic* unconscious, meaning that it results from repression. However, not only is there no report of inhibitory phenomena in the body of the results summarized so far, but, it seems that results in the domain of subliminal priming, using the so-called exclusion paradigm (Jacoby et al., 1992), show the impossibility of unconscious inhibition. In a typical exclusion task, subjects have to produce any word that comes to mind starting with, for example, the fragment YE (i.e. completing a stem target), but they are instructed to avoid the prime word, for example 'yellow'. Debner and Jacoby (1994) have shown that exclusion is no longer possible with subliminal primes (see also Merikle et al., 1995). Instead, subjects complete the fragment with the prime word with higher likelihood than if they are not presented with a word at all. The idea that inhibition requires consciousness seems to be supported by other studies too (for review, see Lau, 2009), including a case study by Persaud and Cowey (2008) of a patient with 'blindsight'. This 'subjectively blind' patient with a lesion to the left primary visual cortex can still discriminate stimuli well above chance level in his blind field in forced-choice situation, but when required to perform an exclusion task, that is, to say the location where the target was *not* presented, he failed to do so in his blind field. Remarkably, he was significantly worse than chance in this field, as if the stimulus drove the response directly and inflexibly. This seems to support the account that consciousness is required for exclusion. The failure to exclude subliminal primes while being influenced by them, then, suggests both a process-dissociation between conscious and subliminal perception, and the impossibility of inhibition has been considered the hallmark of unconscious processing (Debner and Jacoby, 1994; Jacoby et al., 1992; Merikle et al., 2001).

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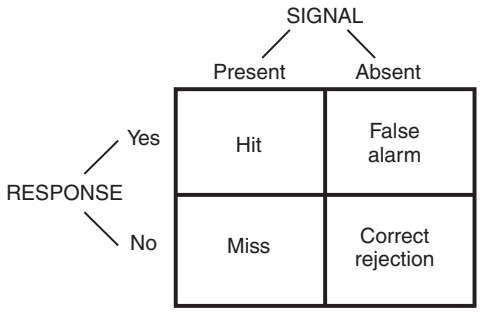

Fig. 18.3 Calculation of hits and false alarms in detection experiments.

However, Snodgrass (2002) has rebutted this exclusion failure argument arguing that these results at the *subjective* detection threshold do not reflect true unconscious processing. Exclusion failure arises from the differential application of exclusion instructions to *weakly conscious stimuli* as a function of confidence. Indeed, exclusion instructions explicitly tell subjects to exclude responses only if they feel they saw the preceding word. If not, they actually are to respond with the 'first word that comes to mind'. In other words, the instruction implies that people don't exclude at low confidence. This account predicts that exclusion failure should disappear if subjects are instead encouraged to exclude even low-confidence stimuli (for example by offering monetary rewards) which is precisely what was shown by Visser and Merikle (1999). Moreover, when working at the more stringent *objective* detection threshold, inhibition results in true unconscious processing can indeed be uncovered (see below).

Robust inhibition results as a function of individual differences with the objective detection threshold methodology in the Shevrin lab[5]

In SDT, a parameter is calculated which indicates the so-called detectability of the stimulus or sensitivity named d′ (*d prime*). To calculate d′, one needs to know a person's hit (H) and false alarm (FA) rates (see Figure 18.3).

d′ then is the standardized difference between the means of the false alarms (FA) and hits (H) distributions: $d' = z(\text{FA}) - z(\text{H})$.[6] Larger absolute values of d′ mean that a person is more sensitive to

[5] The 'Shevrin lab' is actually the Ormond and Hazel Hunt ERP Laboratory at the University of Michigan. It has been in existence since 1980 and is part of the University of Michigan Program of Research on Unconscious Processes, which is considered one of the leading programmes devoted to investigating unconscious processes. The Michigan programme was preceded by a loosely organized group of investigators both at the Menninger Foundation where the research began and at the University of Michigan. Throughout this time the programme has been directed by Howard Shevrin, an experimental psychologist and psychoanalyst. The research programme has two programmatic goals: (1) to establish the existence and nature of unconscious processes, and (2) to investigate qualitative differences between conscious and unconscious processes related to the psychoanalytic distinction between primary and secondary processes. Throughout this chapter, references are made to individual publications emerging from the programme. The authors of these studies aside from Shevrin have been Michael Snodgrass, Linda Brakel, Edward Bernat, Philip Wong, Scott Bunce, Ramesh Kushwaha, William Williams, Robert Marshall, Ariane Bazan, Samuel Winer, Richard Hertel, and James Bond.

[6] Thus, z(FA) and z(H) are the z scores that correspond to the right-tail p-values represented by FA and H. For example, a false alarm rate of 0.30 indicates that when the signal is absent the subject nevertheless says 'yes' 30% of the time. Thus, the right-tail p value on the 'signal absent' distribution is 0.30 and a p value of 0.30 corresponds with a z value of 0.524 (see p to z conversion tables). A hit rate of 0.90 indicates that when

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the difference between the signal present and signal absent (or 'noise') distributions. In subliminal priming, it is crucial that the d′ of the direct task for the conscious perception is not significantly different from zero, that is, the subject cannot make a distinction between signal and noise, resulting in an at-chance performance.

For different direct tasks, such as, for example detection, identification, and categorization, subjects will have different d′ values.[7] Importantly, presentation times corresponding to a d′ not significantly different from zero for a categorization task will yield a slightly positive d′ for an identification task at the same presentation conditions. Similarly, at conditions a bit more stringent (e.g. shorter presentation times) where d′ for identification now becomes equivalent to zero, d′ for detection will still be slightly positive. Concretely, this means that at presentation times were conscious categorization is at chance, conscious identification is slightly above chance. Similarly, at conditions where conscious identification is at chance, detection is slightly above chance. Now, it is important to indicate that for all subliminal priming studies, discussed so far, either subjective threshold methodology was used, or if objective measures were used, then the direct CPI task was never as stringent as a detection task, mostly being an identification or categorization task. However, together with the psychoanalyst Shevrin, the second author has developed a model called the *objective threshold/strategic model*, which holds that conscious perceptual influences typically override unconscious ones on the experimental task when both are present (Snodgrass and Shevrin, 2006; Snodgrass et al., 2004). Consequently, unconscious perceptual effects are obtained most reliably only when conscious perception is *completely absent*, that is, when measured at the very stringent presentation conditions of the *objective detection threshold where detection d′ is not significantly different from 0*.[8] This model holds that *in those conditions objective threshold effects are genuine and not short lived*.

Using this stringent methodology, Shevrin and colleagues have accumulated a body of subliminal priming results. While most research teams shy away from ultra-brief presentation times, fearing nothing at all will be processed, Shevrin and colleagues have shown that these kind of subliminal stimuli elicit ERP patterns that are structured similarly to ERP patterns evoked by supraliminal stimuli at all electrodes, be it at a lesser amplitude (Bernat et al., 2001a,b; Shevrin, 1973; Shevrin

the signal is present the subject only says 'yes' 90% of the time. Thus, the right-tail *p* value on the 'signal present' distribution is 0.90 and a *p* value of 0.90 corresponds with a *z* value of –1.282. The d′ in this case will be 0.524 – (–1.282) = 1.81.

[7] Take, for example, the two words: 'rose' and 'fighting'. Subliminal presentation of these words can be subject to different forced-choice tasks. In a *detection task* the subject will simply be asked if either a stimulus ('something') or a blank card ('nothing') was shown to him, knowing that half of the trials are stimulus cards and half of them are blank cards and that they are randomly distributed. In an *identification task* the subject will be asked to tell which of the two words (known to the subject) is presented. In a *categorization task* the subject will be asked to judge, for example, the emotional valence (positive or negative) on each subliminal presentation. In detection hits and false alarrns are straightforward: a hit is when a stimulus is rightly detected and a false alarm is when the participant indicates the presence of a stimulus while a blank card was presented (see Figure 8.3). In identification a hit is when the participant says 'rose' when 'rose' is presented, and a false alarm is responding 'rose' when 'fighting' is presented. Note that the same d' will be obtained if d′ is calculated the other way around (e.g. defining hits as responding 'fighting' when 'fighting' is presented). In categorization a hit is when 'positive' is responded when 'rose' is presented, and a false alarm is responding 'positive' when 'fighting' is presented. Again, the same d′ will be obtained if d′ is calculated the other way around.

[8] Concretely, these very stringent conditions are realized either by using a tachistoscope and presenting stimuli at one millisecond, followed by an energy mask, or by using a cathode ray tube display and presenting stimuli at 7 milliseconds (lower boundary for the refresh rate), followed by a pattern mask.

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and Fritzler, 1968). Moreover, *subliminal semantic priming* was shown in a study by Klein Villa and colleagues (2006). In this study a subliminal prime, presented in the tachistoscope at 1 ms, such as 'dog' was able to prime the preferential choice of the supraliminal target 'canine' as compared to the distracter target. However, this effect was not found as a main effect, that is, it was not found as an effect or tendency over the whole group of participants. Instead, it was found as *an interaction effect with personality factors*. Indeed, in agreement with psychoanalytic metapsychology, it was presumed that unconscious processes would vary—that is, have other dynamic principles—in function of personality structure, especially in function of the defensive mode. For this reason, a variety of personality factors are measured routinely in each subliminal priming study done at the Shevrin lab, including defensivity (operationalized as 'social desirability'; Crowne and Marlowe, 1960), mode of defence (measured by the 'hysteroid obsessoid quotient' or HOQ; Caine and Hope, 1967), and anxiety. In the Klein Villa study, it was found that participants with high trait anxiety showed facilitation for semantic priming. Remarkably, participants with low trait anxiety did not show an absence of semantic priming, but an *inhibition*, meaning that they chose the distracter at higher levels than chance. Remarkably, it was also shown that 'dog', which is the reverse word of 'god', was able to prime for 'angel' in high anxious people, while in low anxious people the palindrome choice was significantly avoided (i.e. the semantic associate of the palindrome was chosen significantly *less than chance).* In the supraliminal control experiment, primes shown fully consciously were able to prime for the 'forward' semantic target but *not* for the palindrome semantic target. An important aspect of the Klein Villa et al. results was that the reported interaction effects were even stronger when stimulus detectability was low than at higher levels of detectability. This not only rules out any sceptical account that the measured effects might be due to residual conscious perception, but moreover, it is in agreement with the Snodgrass and Shevrin model, which proposes that any residual conscious perception reduces rather than enhances the unconscious effects.

Inhibition effects, that is, *results significantly below chance*, have been repeatedly found by Shevrin and colleagues, starting with the 1993 paper by Snodgrass and colleagues. In this study, participants were asked to do an identification task (i.e. the UPI) while subliminality was verified by a detection task (i.e. the CPI). One of four words, known to the participants, was presented at 1 ms and the participant had to identify which of the four words was presented. The detection d′ in the experiments of this study (as in the later replications) was not significantly different from zero. Overall identification by the participants was not significantly different from chance, that is, there ~~were~~ no main identification effect. However, participants were asked to use one of two strategies in order to identify the stimuli: in the *look* strategy, subjects were instructed to attend carefully to the visual field and look hard for any trace of the stimuli; in the *pop* strategy, subjects were urged to allow one of the four stimulus words to pop into their heads—to say whichever of the four words comes to mind. Following the completion of the two strategy conditions, subjects were asked which of the two conditions they preferred. The 1993 experiment was replicated both in the Shevrin lab (Snodgrass and Shevrin, 2006) and by Van Selst and Merikle (1993). The main consistent finding in the original experiment and in its replications (see Table 18.1), then, was that 'poppers' facilitated slightly in the pop condition ($p = 0.035$), while 'lookers' did better than chance in the look condition ($p = 0.000114$) and performed *significantly below chance* in the pop condition ($p = 2.98 \times 10^{-7}$; p values of the meta-analysis, Snodgrass and Shevrin, 2006).

Most importantly, this looker inhibition result correlated again *negatively* with stimulus detectability: that is, the lower the d′, the more the lookers performed below chance in the pop condition. Taken together, these data showed that the subliminal inhibition effect is very robust. The only way to understand this result then, is that 'when utilizing the strategy congruent with their preference, perhaps participants unconsciously allow this activation to influence their

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Table 18.1 Meta-analysis of the pooled data of the 'pop-look' experiments

	Strategy	
Preference	Pop	Look
Pop (*n* = 139)	25.74 (4.12)	24.71 (4.55)
Look (*n* = 105)	23.06 (3.64)	26.40 (3.59)

Standard deviations and *n*s are in parentheses. Mean performance is percentage correct (chance = 25). See text for significance levels.

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response, elevating performance above chance. In contrast, when utilizing the incongruent strategy, such influences are *unconsciously rejected* and below-chance performance ensues' (Snodgrass and Shevrin, 2006, p. 63, original emphasis). The looker inhibition then 'might reflect a simple form of *unconscious defense*, . . . Along these lines, lookers consistently expressed a strong preference for activity and control, explaining that they disliked "doing nothing" as the pop instructions required. Obliging lookers to relinquish conscious control with pop instructions might instantiate a mildly conflictual situation, producing inhibition, whereas more congenial look instructions would not, yielding facilitation' (Snodgrass and Shevrin, 2006, p. 63). In other words, it seems quite impossible to make sense of these results without assuming the existence of unconscious inhibition, the dynamics of which (only) seems to make sense in a psychodynamic interpretation.

Going back to the Klein Villa study, how can we then make sense of the unconscious avoidance of semantic associates at low levels of trait anxiety? We propose that this semantic and phonological associativity reflects a primary process dynamical organization that is thought to be under inhibitory control of the secondary process such as described by Freud (1895, 1900; see also Bazan, 2006). Uncontrolled free association constitutes a threat because it may lead to the revelation of uncomfortable subjective truths such as in parapraxes, dreams, or during free association. Therefore, a 'good' defensive organization may imply an effective inhibition of this association. Anxiety interferes with the organization of defence; therefore people with structurally higher levels of anxiety might not be able to defend as efficiently and show associative facilitation, explaining the present results. Alternatively, it might also be that people, who on a paper-and-pen questionnaire claim to be usually less anxious, are more defensive than people who admit more anxiety experience. Thus the low anxiety would be an indication of an efficient defensive organization, resulting in inhibition of association. This seems to be confirmed in the preliminary results of a new study with phonological palindromes showing inhibition of the phonological palindrome choice in high defensive participants (Bazan et al., 2008).

The Shevrin lab results summarized so far are indicative of an inhibition happening unconsciously and suggestive of a defensive personality style. Another type of inhibition results have also been found in the Shevrin lab, indicating that presumably repressed material is unconsciously present but is not used consciously. Together with three colleagues psychoanalysts, Shevrin undertook a study with participants suffering from social phobia (Shevrin et al., 1996). A number of psychoanalytic interviews were conducted with each participant, aimed at understanding the underlying unconscious conflict to the phobia and at selecting words that were related to that unconscious conflict, as well as words that indicated how participants consciously experienced their symptom. These words, together with control words, were then presented both subliminally and supraliminally to the participants and ERPs were collected. In other words, a particular set of prime words was constituted for each participant. The main results, then, were that when the

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unconscious conflict words were presented subliminally (at 1 ms) the brain waves of those words could be classified as going together on the basis of common brain ERP features.[9] Remember, these words were *inferred* by the analysts from the conscious story brought by the participants; they were at no point indicated as such by these participants, let alone indicated by them as pertaining to the conflict underlying their symptoms. The brain waves related to the conscious symptom words did not show common features. On the other hand, when the same words were presented supraliminally, the brain waves no longer put the unconscious conflict words together but they did a better job ~~of~~ putting the conscious symptom words together. Moreover, the experimental effect correlated highly with HOQ repressiveness: the more repressive, the better the brain waves put the unconscious conflict words together subliminally than supraliminally. To interpret these results, Shevrin and colleagues suggest that when the unconscious conflict words are presented consciously, there is a repressive inhibitory process at work which keeps the subject's brain and conscious awareness from seeing any relationship among these words, and this all the more with higher repressiveness (Shevrin et al., 1992).

In conclusion, we propose that working at the stringent conditions of the objective *detection* threshold for subliminal priming does make a difference. The idea is that only in these conditions one is able to uncover the deep unconscious inhibition and defensive characteristics of the Freudian unconscious. In their taxonomy, Dehaene and colleagues (2006,)[10] define *subliminal processing* as a condition of information inaccessibility where bottom-up activation is insufficient to trigger a large-scale reverberating state in a global network of neurons and is therefore insufficient to realise conscious access. While subliminal processing is defined as unreportable and unaccessible, Dehaene and colleagues (2006) and others (Greenwald et al., 2003; Kunde et al., 2003) report that, contrary to what was thought previously, conscious indications or task instructions, are able to strategically influence this processing. We propose, however, that this kind of subliminal processing still reflects weak conscious processing characterized by unreportability and unaccessibility and corresponding to the 'phenomenally conscious' (cf. Block, 2005, 2007; Snodgrass and Lepisto, 2007; Snodgrass et al., 2009). We propose that there is a different form of subliminal processing which we would call *(deep) unconscious* processing, which is also characterized by unreportability and unaccessibility, but the dynamics of which are moreover not sensitive to conscious strategic instructions in a straightforward manner but are structurally sensitive to subject factors, which are primarily related to the subject's defensive organization, such as trait anxiety and defensivity. Characteristic for this kind of deep unconscious processes is that they behave differently in different subjects; this implies that there are seldom main effects to be observed experimentally in subliminal priming at the objective detection threshold, but that the unconscious effects are uncovered when personality structure information is taken into account. In this framework, implicit information processing as described in neuropsychological case studies or, for example, in blindsight (see 'Other search results' below), are considered as subjective threshold phenomena (Snodgrass and Shevrin, 2006) at the level of the phenomenally conscious and

[9] These are time-frequency features: an ERP is a time series of brain response to stimuli measured on the scalp; 'fast Fourier spectrum' transformation converts a time series into a frequency domain data that depicts energy or power at each frequency. A time-frequency distribution provides a view of power for each time and frequency bin.

[10] Dehaene and colleagues (2006) propose a difference between preconscious and unattended and attended subliminal processing, all three being characterised by unreportability. The *preconscious* is defined, referring to Freud, as a neural process that potentially carries enough activation for conscious access, but is temporarily buffered in a nonconscious store because of a lack of top-down attentional amplification; stimuli are potentially accessible but are not consciously accessed.

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characterized by unreportability. The uncovered defensive mechanisms, although proper to the neuropsychological condition, are not sensitive to personality factors, and might therefore be of a different kind than the unconscious inhibition mechanisms observed at the objective detection threshold.

Unconscious inhibition of motor control

Intention to move

Since the seminal work of Libet and colleagues (Libet, 1985; Libet et al., 1983) it is known that the readiness potential (RP), a gradual increase in electrical activity in the motor cortex that precedes willed actions by one second or more, precedes the moment at which subjects first become aware of their will to move by 200–500 ms. In other words, a person's conscious experience of intending to act *follows* the RP. A network of cortical regions within the dorsal medial frontal cortex has been identified as the neural substrate in the voluntary control of intentional actions (Passingham, 1993). In particular, the supplementary motor area (SMA), supplementary eye field (SEF), and the pre-SMA have been implicated in the control of actions that are self-initiated or driven by internal goals (e.g. Isoda and Hikosaka, 2007; Lau et al., 2004; Nachev et al., 2005; Tanji and Shima, 1994). Hallett proposed (2007) that movement is initiated in frontal lobe on the basis of its several (prefrontal and limbic) inputs.[11] The movement command goes to the primary motor cortex with an efference copy to the parietal area and the conscious sense of volition most likely arises as the result of this efference copy (Hallett, 2007). In other words, the motor system generates a movement and, in parallel, signals are generated which produce the subjective experience of willing to execute that action, which is perceived as being freely chosen. Libet (1985) indicates that while actions appear not to be freely initiated, they may be freely stopped. Indeed, because awareness of intention precedes movements by some hundred milliseconds, there is still time to consciously withhold the upcoming action. This veto power, or 'free won't' would therefore be the basis of our freedom to choose our actions. Brass and Haggard (2007) show that it is a specific area different from the SMA or pre-SMA, namely the left dorsal fronto-median cortex (Brodmann's area 9), which is specifically associated with this conscious suppression of self-initiated actions.

Conscious experience of the will to move

However, perhaps it is not the intention to move as such which generates the *conscious experience of the will to move*. Haggard and Eimer (1999) showed that awareness of intention correlates better with a later component of the RP, the lateralized readiness potential (LRP). LRP reflects the electrical activity over the motor cortex opposite to the limb that will move. Since the motor system must have selected which specific movement to perform by the time that the readiness potential lateralizes, Haggard and Eimer (1999) proposed that awareness of movement may arise from neural processes linked to the *selection* of an action to pursue a given goal and not to the earliest initiation of action processes.

This makes sense: as indicated by Sumner and colleagues (2007), a defining criterion for voluntary behaviour is that the stimulus environment does not inevitably specify one particular movement. In other words, there is choice and therefore contingency, because more than one action may be

[11] Recently, it was shown that a network of high-level control areas begin to shape an upcoming decision long before it enters awareness (Soon et al., 2008): the earliest unconscious precursors of the motor decision presumably originate in frontopolar cortex, from where they influence the build up of decision-related information in the precuneus and later in SMA, where it remains unconscious for up to a few seconds. More precisely, it was found that the outcome of a decision can be encoded in brain activity of prefrontal and parietal cortex *up to 10 seconds* before it enters awareness.

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associated with the current conditions. Voluntary behaviour thus implies a potential for coactivation of action plans (Nachev et al., 2007). Therefore it has been widely accepted that some form of motor inhibition is at play for action selection. This has been shown for the LRP in subliminal motor priming experiments. Indeed, parallel to what was discussed earlier on the unconscious inhibition of mental representations, a wealth of results have also been obtained in the domain of subliminal motor priming. These subliminal priming paradigms (e.g. Eimer and Schlaghecken, 1998) typically present primes—mostly arrows pointing to the right or to the left—for 16 ms, followed by a 100 ms mask; targets are again arrows pointing in the same or in the opposite direction; participants typically are asked to make key-press responses with their left or right hand depending on the side pointed to by the arrow in the target. Forced choice discrimination tasks on the primes show random identification performance, confirming their subliminal status. The results show that the subliminal primes initially activate a motor response, inducing positive priming for compatible trials. However, at longer SOAs (stimulus onset asynchrony), this activation is followed by an inhibition, inducing negative priming on compatible trials (this is the so-called 'negative compatibility effect' or NCE; Eimer and Schlaghecken, 1998), that is, due to the inhibition of the specific movement (the same in prime and target) reacting upon the target is delayed. Depending on the authors, this inhibition is considered as either a spontaneous inhibition of reactions induced by subliminal stimuli if these stimuli remain unconfirmed by stronger information or if they suddenly stop (self-inhibition hypothesis; Boy and Sumner, 2010; Schlaghecken and Eimer, 2002) or as an inhibition due to new competing information brought by the mask or by flankers (Boy et al., 2008; Jaśkowski, 2007, 2008). Most accounts agree on the existence of mutual inhibitory connections between response alternatives (see Sumner et al., 2007). Praamstra and Seiss (2005) proposed that alternating cycles of activation and inhibition are inherent in the competitive interactions between response alternatives, perhaps due to a mechanism that detects and opposes large activation differences. Moreover, Sumner et al. (2007) demonstrated that the SEF and the SMA are critically involved in this unconscious suppression of unwanted responses elicited by the surrounding context. It is this unconscious inhibition process then which realizes the selection of an adapted movement in function of the environment. Paradoxically, this unconscious inhibition might then eventually yield the first conscious awareness of the will to act, perceived as free will. This conclusion is coherent with Jeannerod (1994), who proposed that it is precisely the inhibition of action which renders its imagery conscious, while without inhibition an action preparation comes to execution without the need for conscious intervention.

Among the multiple triggers for movement (see also Bargh and Morsella, 2008), action-related *objects* can activate multiple action plans in parallel: indeed, findings suggest that ambient stimuli automatically set us to physically interact with the world (e.g. perform a power grip, Tucker and Ellis, 2001). Moreover, the physical behaviour (posture, facial gestures, arm and hand movements) of *people* elicits others to behave in the same way, without them intending to or being aware they are doing so. Bargh and Morsella (2008) add that this unconscious imitation also tends to increase bonding between individuals, serving as a kind of natural 'social glue'. Furthermore, at a more complex level of behaviour, research has also demonstrated effects of subliminal stimulation on goal pursuit. Recently, indeed, Custers and Aarts have summarized a wealth of results which show that 'people become motivated to initiate and exhibit behaviours available in their repertoire when goals that are represented as desired outcomes are primed, even though they are not aware of the primed goal or its effect on their motivation and behaviour' (2010, p. 48). For example, results show increased task performance after priming of achievement-related words (Hart and Albarracín, 2009), enhanced fluid consumption in a taste task after priming of drinking-related words (Strahan et al., 2002), and an increase in instrumental behaviour leading

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to specific goals (such as helping another person) after priming of names of occupations associated with these goals (such as nurse; Fitzsimons and Bargh, 2003).

If flexible behaviour is to be possible, though, such automatic motor activation must be inhibited and free initiative must be mediated by selective disinhibition. In other words, with choice comes the need to inhibit any response activation triggered by the environment which would otherwise interfere with ongoing motor plans. This unconscious inhibition then is different from the *conscious* decision to suppress a movement that was already initiated as indicated higher. Crucially, it is the unconscious inhibition that is thought to enable the conscious experience of the will to move, and thus it is this unconscious inhibition which subsequently enables the possibility of conscious suppression of self-initiated action.

Suppression and inhibition in memory and language processing

The necessity to inhibit competing alternatives in order to achieve directed behaviour turns out to be a general principle of mental functioning. Not only does this principle operate in action selection, but research shows that it is also working both in memory and language processing.

In memory research, several studies have shown that the act of recall reduces access to related memories, a phenomenon known as 'retrieval-induced forgetting' (e.g. Anderson et al., 1994, 2000; Bjork et al., 1998). Anderson and colleagues show that this forgetting is caused by inhibitory processes inherent to recall: an attentional inhibition process suppresses competing items in order to focus the search for retrieval targets (Anderson and Spellman, 1995; Anderson et al., 1994; Johnson and Anderson, 2004). Anderson and Bell (2001) show that the consequence can be an enduring impairment for the interfering facts, which may generalize to associated facts (see also Anderson and Spellman, 1995). When people regularly use some of the facts about a topic selectively, they risk more rapidly forgetting related facts that go unused. Furthermore, Anderson and Green (2001) show that when people encounter cues that remind them of an unwanted memory and they consistently try to prevent awareness of it, the later recall of the rejected memory becomes more difficult. The forgetting is caused by processes that suppress the memory itself and this suppression has enduring consequences. Anderson and colleagues (2004) show that controlling unwanted memories is associated with increased dorsolateral prefrontal activation and reduced hippocampal activation. Recently, Depue and colleagues (2007) have shown that emotional memories are initially suppressed by the right inferior frontal gyrus, followed by the right medial frontal gyrus over regions supporting sensory (visual cortex, thalamus), respectively emotional components of the memory representation (hippocampus, amygdala). Interestingly, the authors mention that their data 'also provide an intriguing hint that, as suggested in clinical practice, it is necessary to "revisit" an emotionally distressing memory before it can be controlled, p. 218'.

In language research, it has been known since longer that normal language processing requires an online *structural* inhibitory intervention. Not only do homonyms—that is, words with multiple meanings such as 'match'—exhaustively activate all meanings present in memory for a very short period of about 100 ms (e.g. Onifer and Swinney, 1981; Seidenberg et al., 1982; Swinney, 1979) but moreover, because there are no pauses between words, language is polysemic in nature, independently of the presence of homonyms. For example, Cutler and colleagues (2002) indicate that an apparently unambiguous phrase such as 'We stop begging' transiently activates the meanings of the intermediary words 'east' between 'We' and 'stop' and 'egg' in 'begging'. This activation is so transient that we do not become conscious of it. Before 100 ms (about three syllables) have elapsed an active, energy-costing inhibition process intervenes which inhibits all non-contextual meanings (Faust and Gernsbacher, 1996; Gernsbacher and Faust, 1991; Gernsbacher and Robertson, 1995; Gorfein et al., 2000; Paul et al., 1992; Simpson and Kang, 1994). Interestingly, it is by the

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spill-over of this inhibition that we may have a hint of its existence. For example, Gernsbacher and Robertson (1995) show that if a phrase ending in a polysemic word used in one of its meanings such as 'He lit the *match.*' is immediately followed by a phrase using that same polysemic word in another meaning (e.g. 'He won the *match.*') a measurable delay of comprehension is observed. Indeed, for a correct disambiguation of the sentence, the first encounter of 'match' has induced an inhibition of its non-contextual alternative meanings, which has not yet completely recovered to baseline when arrives the second sentence. This second sentence however needs the previously inhibited meaning for a correct understanding, thereby causing a slight delay in comprehension. Moreover, it has been shown that this inhibitory effect for the subordinate meanings is exercised by the left prefrontal cortex (Atchley et al., 1999; Burgess and Simpson, 1988; Chiarello, 1985).

In conclusion, although inhibition in memory and language are still controversial issues, these recent studies suggest that inhibitory processes can be experimentally studied and their neural correlates are beginning to be specified. While the memory results pertain to conscious retrieval and associated suppression processes, the language results pertain to unconscious multiple activation and associated inhibition processes. However, the patterns for action, memory, and language are the same: multiple activation brings about the need to eliminate competing alternatives and it is this elimination of alternatives which results in the selected response to acquire a consciousness advantage.

Other research results

Besides the subliminal priming research, a number of other experimental approaches have yielded results pertaining to unconscious defensive processes, including hypnosis research enabling brain imagery and investigating inhibition in hysterical conversion (Raz and Wolfson (Chapter 19) and Oakley (Chapter 20), this volume) and neuropsychological case studies of brain lesion patients with various syndromes. For example a number of studies have demonstrated that patients with deficits in certain conscious processes, such as episodic memory, perception, or self-awareness, may nevertheless be able to implicitly process such information. For example, implicit processing has been demonstrated in hemispatial neglect (Marshall and Halligan, 1988), blindsight (Weiskrantz et al., 1974), prosopagnosia (Tranel and Damasio, 1985), amnesia (Johnson et al., 1985), and more recently anosognosia (e.g. Fotopoulou, 2010; Ramachandran, 1995, 1998) or somatoparaphrenia (e.g. Morin et al., 2005). Furthermore, in some of these syndromes the lack of conscious processing seems to be actively maintained by the existence of organized defensive behaviours along the lines described by Freud (cf. Fotopoulou, 2008; 2010; Fotopoulou and Conway, 2004; Fotopoulou et al., 2010; Morin et al., 2005; Nardone et al., 2007; Ramachandran, 1994).

Speculations on the physiology of repression

Consciously and unconsciously induced repression

Anderson and Green (2001) and Conway (2001) have defended the idea that the induced forgetting findings provide a viable neurobiological model of repression understood as the forgetting of unwanted memories by pushing them away into the unconscious. This, they claim, lends support to Freud's original definition of repression: it shows the existence of consciously initiated, executive inhibition of memory. There is a common element in the inhibition processes described for memory, action, and language and which is well known to clinicians, namely the so-called 'spill-over' of the inhibition. Inhibition betrays itself through being *too* efficient and including associated elements which were not a target in the first place. In the memory research, avoiding unwanted memories is reported to induce forgetting of associated elements. For action selection, Sumner et al.

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propose: 'On occasions, such automatic [inhibition] mechanisms might appear maladaptive, suppressing actions that are subsequently required' (2007, p. 699). This is dynamically similar to the 'match' example cited higher in language processing. Compare these instances to the forgetting of *Signor*elli by Freud (1901): this forgetting, he explains, is due to the spill-over of the inhibition imposed by him on the phrase '*Herr*, was ist da zu zagen' ('Sir, what can I say') a fragment of a memory on the sexual mores of the Turks which came to his mind but which he pushed away because it was not a decent topic of conversation. While pushing away 'Herr', Freud also pushed away its close associates, such as the Italian translation of this word, 'Signor' and its compounds, among which 'Signorelli'. In this sense, the model proposed by Anderson and Conway illustrates a process which corresponds dynamically to the Freudian model of repression.

Nevertheless, these induced forgetting findings concern a *consciously initiated* inhibition of memory. It appears problematic to limit the concept of repression to a consciously initiated process: this is not what is proposed in Freud's original metapsychology (see section 'Metapsychology of Freudian repression' above; cf. Erdelyi, 2006 for a discussion of this point), and it is also not in accord with clinical observation. Again, the forgetting of the name 'Signorelli' is a good illustration of this point (Freud, 1901, pp. 2–7). Instead of the name 'Signorelli' two substitutes actually came to Freud's mind, 'Boticelli' and 'Boltraffio'. For 'Boticelli' it seems that it is composed by the original ending -elli upon which no repression was exercised, and the first part 'Bo', which by being metonymically associated to the compound 'Bosnia—Herzegovina', refers to the defensively targeted syllable 'Herr'. The substitute 'Boticelli' then is the return-of-the-repressed substitute of a *conscious* instance of suppression since Freud remembered very well that he purposely pushed away an anecdote starting with '*Herr*, was ist da zu zagen . . .'. However, the substitute 'Boltraffio' seems metonymically associated to 'Trafoi', a city in Herzegovina, where a patient of Freud, desperate due to an incurable sexual dysfunction, had recently killed himself. Freud had no memory whatsoever of this patient having crossed his mind during the conversation, even if it would have been logical given the similarity in themes, namely death and sex. However, given the closeness of the syllables '-traffio' and 'Trafoi', Freud then had to assume, that is, to reconstruct, that this painful event must have nevertheless been mentally present but that it was inhibited and created the return-of-the-repressed substitute of an *unconscious* instance of repression, 'Boltraffio'. Similarly, during the course of a clinical journey, a subject comes to encounter both insights of which he might say: 'I knew it all along' and conjectures he has to assume in order to make sense of his own behaviour but which seem alien to him, as if they originated from '*den anderen Schauplatz*', from a strange place.[12] For these last instances the blocked access to these insights was probably not consciously initiated. In this context it seems very interesting that the Shevrin lab research shows at least two kinds of experimental results: in some studies, behavioural and brain results demonstrate that there is a knowledge which is not consciously used but is nevertheless present unconsciously (and physiologically; e.g. Shevrin et al., 1992, 1996) and another series of results indicates inhibition at an unconscious level, where access to potential information is *unconsciously* (and physiologically)[13] *avoided* (e.g. Klein Villa et al., 2007; Snodgrass et al., 1993). In this respect, it must be stressed that the language and action research cited above uncovers a process of ambiguity resolution which takes place *before* awareness of the initiative arises: the inhibition is initiated unconsciously and there is no conscious access to the activated contents which are not selected for execution. Moreover, interestingly, for action and language, there are strong suggestions that it is the selection process itself which is constitutive of the becoming aware.

[12] cf. the famous '*ça parle*' ('id/it speaks') of Lacan (1964).

[13] Preliminary results of Bazan et al. (2008b).

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This is markedly different from the induced forgetting results describing a conscious intention of pushing away of the unwanted memory which has first come to consciousness.

Indications of reality versus efference copies

How, then, can we think of the described inhibitory selection mechanism at a physiological level? In the metapsychological introduction we have seen how Freud puts language and action on a same level in the mental apparatus: 'A presentation which is not put into words, or a psychical act which is not hypercathected, remains thereafter in the Ucs.' (Freud, 1915b, p. 186). This is important because we propose that Freud's model can be most productively read in a sensorimotor perspective. In Freud's most neurological account on repression—in his 'Project for a scientific psychology' (1895)—he described two fundamental modes of mental treatment: the primary process and the secondary process. While the primary process will treat all incoming stimuli (both entering from the environment and from the body) as probes activating associated action plans, the secondary process will inhibit execution of these action plans, unless a reality check releases this inhibition. The reality check is realized by what Freud called the 'indications of reality' and which he characterized neuro-anatomically: 'In the case of every external perception a qualitative excitation occurs in ω . . . [this] ω excitation leads to ω discharge, and information of this, as of every discharge, reaches Ψ' (Freud, 1895, p. 325). In this definition, ω neurons are a system of motor neurons which are engaged in the constitution of perception—thus, you could think of them as oculomotor neurons, for example—and Ψ is a system of cortical neurons with memory capacity responsible for psychical processes in general (Freud, 1895). Freud adds: 'The information of this discharge from ω is thus the indication of quality or of reality for Ψ' (1895, p. 325). Since information of the ω discharges is only produced when there is active perception mobilizing the ω neurons—for example when there is scanning motor activity in the case of vision—this information then furnishes a criterion to distinguish external perceptions from internal images, that is, it allows 'a discrimination between memory and perception' (Shevrin, 1998, p. 252).[14] For example, the criterion distinguishes the imagined breast from the perceived breast and only in the latter case, sucking action is released. We might say that in the case of an imagined breast, the inhibited sucking action 'is not hypercathected, remains thereafter in the Ucs.', that is, we have here a very basic form of repression.

Earlier, the first author has defended the idea that Freud's 'indications of reality' correspond with the 'efference copies' of the modern sensorimotor models (see Bazan, 2007a,b; Bazan, 2008). Efference copy models (see Figure 18.4) are computational models which propose that upon motor preparation and intention, copies of the efferent motor information are fed back and used centrally in an emulation algorithm, which calculates the anticipated somatosensory changes expected as a consequence of the prescribed motor execution. Upon effective execution, the actual proprioceptive feedback of that action will then (more or less) balance out the predicted sensory feedback in the parietal somatosensory cortex (at the level of a so-called 'comparator').

The modern efference copy models are derived from von Helmholtz' original model which first proposed the idea of direct sensation of the motor command: 'The impulse to move, which we initiate through the innervation of our motor nerves, is immediately perceptible.' (von Helmholtz, 1878, p. 123). This idea was later integrated in motor physiology as the 'corollary discharge' by van Holst (1954) and Sperry (1950), and recently reintegrated in the efference copy model in

[14] Shevrin even proposes more generally that 'The function of consciousness as subjective awareness in any state is to distinguish the actual source of a mental content and to reveal the source as a quality or category of experience' (1992, p. 137), these categories referring to mental vehicles such as perception, memory, thought, desire, and so on (Shevrin, 1998).

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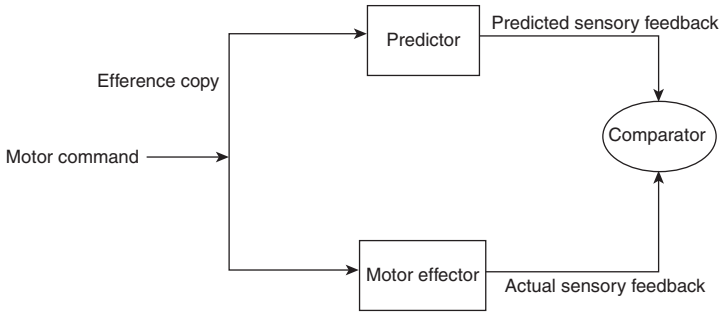

Fig. 18.4 The efference copy model (Blakemore et al., 1998b; Georgieff and Jeannerod, 1998; Sperry, 1950; van Holst, 1954).This computational model proposes that upon motor preparation and intention, copies of the efferent motor information are fed back and used centrally in an emulation algorithm, which calculates the anticipated somatosensory changes expected as a consequence of the prescribed motor execution. Upon effective execution, peripheral changes ~~at the level of the muscles, the joints and the skin~~ generate an actual proprioceptive feedback, which will (more or less) balance out the predicted sensory feedback in the parietal somatosensory cortex (at the level of a so-called 'comparator').

sensorimotor neurosciences by Blakemore et al. (1998b), Wolpert (1997), Jeannerod (1997), Frith and colleagues (2000) and others. Freud adhered to the views of the late nineteenth century physiology school—called 'physikalischen Physiologie'—of among others, von Helmholtz, Wundt and Brücke. It is probable that Freud's model of the mental apparatus was inspired by von Helmholtz' insights on the motor control of perception. In *On Aphasia*, for example, Freud (1891, p. 73) indeed uses the concept of "impression of word innervation' [*Wortinnervationsgefühl*], next to and different from the 'kinaesthetic word image' [*Sprachbewegungsvorstellung*], the sensory impressions from the organs of speech: these 'innervation impressions' then logically refer to von Helmholtz' concept of immediately perceptible impression to move. In the *Project* Freud (1895, p. 325) proposes that the 'indications of reality' are given by 'the informations of discharge', or, this is to say, literally from Freud's text, the 'Abfuhr Nachrichte', or 'efference messages', which 'as for every efference message' flow back to the central nervous system (Freud, 1895, p. 325). The neuro-anatomical and even semantical closeness of Freud's concept of 'indications of reality'—also called 'tags' by Shevrin (1998)—and the modern sensorimotor concept of 'efference copies' then is remarkable. There are also functional equivalences: both the psychodynamic and the sensorimotor framework propose that these respective instances are characteristic for *conscious processing*. Elsewhere we have defended the idea that both also have the same functional status in e.g. schizophrenia, enabling the distinction of perceived stimuli from imagined or hallucinated stimuli (Bazan and Van de Vijver, 2009a,b). In summary, a conceptual equivalence or closeness between the Freudian notion of 'indication of reality' and the modern sensorimotor notion of 'efference copy' is proposed. Note that, earlier, Jeannerod and Georgieff (2000) had already indicated Freud's use of a 'comparator system' very much comparable with the modern models for the control of action. These equivalences then will enable us to propose a translation of the psychodynamic model of repression in physiological sensorimotor terms.

A sensorimotor model of repression

Moving the scene of the psychodynamic understanding of the mental apparatus to sensorimotor physiology has many advantages. First, consider Custers and Aarts's seemingly simple conclusions

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in their recent review paper: 'We are able to initiate actions by thinking about their outcomes, because actions and their outcomes are associated on a perceptual, sensory, and motor level. . . . Through prior learning, certain patterns of muscle contraction and relaxation have become associated with their observable outcomes (such as grabbing and lifting a cup). Because of these associations, *bringing to mind the representation* of an outcome prepares and controls perception and action to produce the outcome *without much thought*. . . . *The mere activation of the idea* of a behavioral act or outcome moves and programs the human body *without a conscious decision* to act' (2010, p. 49, emphasis added). Note Custers and Aarts have no difficulties suggesting that routine mental processing such as 'bringing to mind the representation' is supposed to happen 'without much thought' nor that the 'mere activation of the idea' happens 'without a conscious decision'. Implicit to these observations is the seemingly unproblematic notion then that 'representations' and 'ideas' are not to be considered as a priori conscious; conscious mentation is here regarded as merely one possible option for representations and ideas. This is important, because it puts the sensorimotor and the psychodynamic model at the same starting point: probes from the outer (and inner) world continuously activate (historically) associated action plans unconsciously. Moreover, also implicitly acquired in this paragraph is the constitutive link between representation and action: there is no mental representation apart from, next to, or prior to action plans. Here also, psychodynamic and sensorimotor frameworks are similar (see Freud's concept of 'thought as trial action', Pfeffer, 1998). These views turn around the idea that we first think, independently from action planning, then plan action and finally execute action: rather, psychodynamic and sensorimotor models propose that thinking is only possible as an action, as a motor activity—that is, as a motor planning, intention or simulation—and this thinking is not a priori conscious.

To end up with a physiological model of the repression, we now propose to take this reasoning one step further: we propose the idea that mental imagery[15] is not only tied to action, but, crucially, to action inhibition. Bargh and Morsella (2008) have already stressed that inclinations can be behaviourally suppressed, but not mentally suppressed, suggesting that suppressed behaviour is mentally present. But the further idea that inhibited movements are mentally even more influential than perfect movements has also already been proposed by Jeannerod[16] who says: 'If the goal [of an action plan] were not reached, the sustained discharge would be interpreted centrally as a pure representational activity and give rise to mental imagery' (1994, p. 201), while an action that reaches its goal does not lead to this imagery. In other words, it is to the extent that an intended movement is not effectively executed, that representational activity arises centrally. One way to understand this 'mental imagery' is to consider that the anticipatory simulation of action, brought about by the efference copies, has been shown to induce an anticipatory *attenuation* of its expected sensorimotor consequences at the level of the parietal sensorimotor cortex. The particularity of this dynamical organization is its minute precision: this attenuation is not some global decrease but it is an exact point-by-point subtraction of the expected movement (e.g. Blakemore et al., 1998a), that is, it can almost been considered as a formal 'negative' of the movement. When the movement is effectively executed, the preemptive attenuation is resorbed. But, to the precise extent that a movement realisation comes short of exhausting the movement prediction, there is a non-resorbed attenuation rest, that is, a (*negative*) activation rest results at the somatosensory cortex. Moreover, if the movement has encountered unexpected deviations, these will not be attenuated, resulting in a *positive* somatosensory activation. It is precisely these diverse somatosensory activation results which might be understood then as (yielding) the mental imagery.

[15] The term is here used as the generic term for representations and phantoms, and possibly other species of mental imagery.

[16] And by others, among whom Freud, for whom the thinking mind develops out of frustration.

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Speculatively, the negative activation rest has formal characteristics (it specifies a non-realized movement fragment) while the positive somatosensory activation rest might correspond with a selective disinhibition of semantic fields as a result of an encounter with the stimulus (see also Bazan and Van de Vijver, 2009b). Complexifying this organization of selective disinhibition (see e.g. Praamstra and Seiss, 2005), might yield a minute system of targeted associative activation responding selectively to the unpredicted encounters of the subject moving in the world.

To understand the potential *psychodynamic* significance of this organization, the memory and emotion aspects of this organization have to be taken into account. The first moment of action or language ambiguity before conscious awareness leads to exhaustive activation, that is, to the priming of (potentially) all alternatives associated to the stimulus available to the particular subject. Importantly, this first moment is consequential: even if there is an 'exhaustive' activation, this does not mean that there is a universal pattern for all subjects. Indeed, the pattern is still determined by the particular way a subject's history has organized his or her memory. As a consequence, the way in which a subject come to execute a particular action or language fragment might differ only from the way in which another subject comes to execute that *same* action or language fragment by the action or speech alternatives the first subject had to inhibit in order to make this choice. In other words, performing the same behaviour induces a different mental imagery related to motor inhibition as discussed above—that is, *a different mental reality*—in each subject, as well as different spill-over effects potentially readable for others with whom the subject interacts.[17]

Moreover, the emotional importance of the different action choices must be considered. Indeed, the different activation alternatives are likely also encoded in an *emotional* memory system (cf. LeDoux, 1994). Action or speech fragments with a higher emotional valence might pop up more easily and frequently. As a consequence—and particularly in case their effective execution might lead to threateningly high emotional mobilisation of the inner body—these instances might necessitate a higher or a more structural level of inhibition. Hence, they are probably particularly inclined to induce mental imagery (which is not necessarily content-related, cf. the concept of 'phantoms', Bazan, 2007a) as well as spill-overs or substitutes betraying their presence and importance. Hence, in this model, psychodynamic repression is presented as a special instance of a structural, continuous online mechanism of sensorimotor action inhibition which enables targeted (adequate) action contextually adapted to reality. More particularly, this special instance is induced by action (or speech) alternatives which are prominently present in the mental apparatus and which are tied to an important emotional stirring and which for these reasons, call for more intensive and/or more structural inhibition. It is then the consequences of this exaggerated inhibition—namely, the mental imagery and the spill-over behaviours—which render their psychodynamic characteristics to these special instances of inhibition—namely, mental preoccupation and return-of-the-repressed substitutes. For all these reasons, we propose that the efference-copy-linked attenuation mechanism probably constitutes a key to the physiological understanding of psychodynamic repression.

[17] Interacting long enough with an individual subject might therefore create enough opportunities for some such spill-overs to become apparent, informing 'negatively' about the unconscious architecture of the subject's mental apparatus. A common example is the inhibition of an aggressive desire, 'spilling over' to inhibition of all or many aggressive impulses, which becomes readable negatively in a patently accommodating and obliging behaviour. This is a content based example (namely, pertaining to aggressive desires), but clinical analysis shows that it also (logically) applies to form-induced dynamics, such as the forgetting of 'signorelli' induced by the pushing away of 'signor'. This comes close to the Lacanian concept of an unconscious as presented in the seminar on 'The purloined letter': the unconscious is not some behind-the-scenes hidden place but is continuously realized on stage even if not necessarily recognizable as such—it is realized through the subject's actions, and most importantly, through his speech (Lacan, 1955).

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Conclusion and open questions

In this review we have presented empirical results pertaining to the issues of defence and (unconscious) inhibition. Our primary aim is to show that this keystone concept of psychoanalysis is not beyond experimental testing and that, in fact, quite a wealth of research results have already accumulated speaking directly or indirectly to this question. Moreover, we propose that a theoretical model involving efference copies/indications of reality as key concepts can coherently put the various findings together. Having done so, a number of questions do remain open.

First, an important open question is how the experimental laboratory results pertain to the *clinical* phenomenon of repression. There is probably scepticism both from clinicians to consider the subliminal priming results as clinically relevant and from the cognitive neuroscientist to consider the motor or language inhibition results as having a potential psychodynamic nature. We have taken the deliberate stance to distance ourselves from the notion of repression as an exclusively pathogenic process selectively targeting traumatic content (e.g. Brown et al., 1999; Erdelyi, 2006; Pope et al., 1999). We propose to consider the notions of repression and the unconscious as inseparable and to consider the *dynamic unconscious* as a principle of mental functioning, 'the true psychic reality' (Freud, 1900, p. 613). This enables us to discuss repression in the context of action while other authors focus on the forgetting of traumatic memories, making themselves vulnerable to the need to prove such instances of forgetting (e.g. Kihlstrom, 2006; Rofe, 2008). This is not to say that repression is not, in our view, defensive, but the notion of defence is in the first place seen as largely constitutive in enabling humans to make a choice. At the same time, this defence also protects against possibly threatening levels of emotional activation tied to certain alternatives present in memory. In other words, repression enables directed action and ensures a bearable state of mind, at the expense of lost possibilities to attune with reality.

This leads us to a second open question: is defence a content-related event or a content-independent subject factor? The Shevrin lab research indicates that defensiveness influences the way the subject processes *all* stimuli. Indeed, repressive subjects respond with smaller visual evoked potentials to subliminal stimuli as well as fewer verbal associations (Shevrin, 1973; Shevrin et al., 1969, 1970) and have a longer critical time period for consciousness to develop for a somatosensory stimulus (Shevrin et al., 2002). Defensiveness also seems at play in how subjects identify stimuli (cf. the 'pop-look' study) or handle ambiguity (cf. the Shevrin lab language studies). This opens the possibility that it is the defensive style (see also Erdelyi, 2006) which is pathogenically relevant rather than or next to one or a number of instances of repression.

Third, pervading the whole chapter is the question of repression as a consciously initiated process versus resulting from unconscious inhibition. Erdelyi (2006) posits that the difference between conscious and unconscious processing is graded and quantitative and that there is no fundamental difference between unconscious repression and conscious suppression. In this view, the induced forgetting results can stand as a general model of repression. The Libet results uncover the unconscious emergence of intentions to act, followed by a period of conscious awareness allowing for conscious veto to intervene. The question of consciously initiated repression versus unconscious inhibition then might be reformulated in the question if conscious instruction is able to influence action selection before awareness of intentionality arises. Kiefer (2007) would probably answer affirmatively to this question. His results show that masked semantic priming is observed when the preceding task set required the orientation to semantic word features, but not when it required orientation to perceptual word features. Therefore, he proposes that unconscious automatic processes are modulated by top-down factors and he suggests the existence of a gating mechanism which orchestrates the conscious and unconscious information processing streams. These results, then, seem to point in the direction of there being no fundamental difference between unconscious

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Box 18.2 Questions for future study/research

1. To what extent are experimental (laboratory) results on unconscious processes relevant for the clinical situation? To what extent do clinical observations on unconscious phenomena tie into the same fundamental mechanisms observed by scientific laboratory research?
2. Should we consider the psychodynamic notion of repression as a pathogenic process selectively targeting traumatic contents or as a universal principle of mental organization largely enabling normal functioning?
3. Is defence a content-related event or a content-independent subject factor? Is it the defensive style which is pathogenically relevant rather than or next to one or a number of instances of repression?
4. Are there fundamental distinctive differences between conscious suppression and unconscious inhibition?

and conscious processing, both being sensitive to conscious instruction and modulation. This would probably at first sight also fit with the results recently reviewed by Custers and Aarts (2010). Indeed, these authors indicate that subliminal primes that are specifically related to rewards can motivate people to increase the effort they invest in behaviours. Overall they show that there are similar effects of unconscious and conscious rewards on behaviour, concluding therefore that 'conscious and unconscious reward cues have similar effects on effort and flexible cognitive processing' (Custers and Aarts, 2010, p. 49). However, we propose that these different conclusions might not be the end of the story. The Shevrin lab results, using the objective detection threshold methodology, have suggested the existence of (at least) two types of unconscious mental treatment: in some cases, knowledge is not consciously used but is nevertheless present unconsciously (and physiologically) and, in other cases, information seems unconsciously avoided. In the latter case especially, results were only found when the overall priming effects were regressed in function of (more or less) stable personality factors, especially defensivity and the level of anxiety. This might be indicative of a mental treatment which is not consciously adjustable in any arbitrarily chosen direction, but which preferentially responds to more 'hard-wired' (though not necessarily unchangeable) subject factors. In this respect, it is interesting to notice that Custers and Aarts also implicitly refer to such more 'hard wired' influences in the case of their subliminal reward priming results when they say: 'This affective-motivational process relies on associations between the representations of outcomes and positive reward signals *that are shaped by one's history* (for example, when a person was happy when making money or performing well). In this case, the goal is said to preexist as a desired state in the mind' (2010, p. 49, emphasis added). Therefore, we suggest that there are probably fundamental distinctions between unconscious inhibition and conscious repression. Specifically, we propose that the more profoundly unconscious the mental process, the more it is sensitive to hard-wired, individual differences and the less it is strategically or arbitrarily adaptable by conscious influences. This, of course, is very much in line with the psychoanalytic concept of the unconscious.

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