# The emergence of consciousness-state dependent complexity: SEPs and Perturbation Complexity Index in newborns and young infants

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When we fall asleep, conscious processing of sensory events fades. Hence, the comparison between sleep and wakefulness has largely been employed as a model to investigate unconscious and conscious sensory processing. The fading of consciousness during sleep is related to stronger EEG responses and to a breakdown in cortical effective connectivity (1). Accordingly, while the event-related potential (ERP) results larger in amplitude during sleep, the peripheral somatosensory stimulation may lead to a more widespread response during wakefulness. The segregation of brain-responses has been considered a core mechanism that preserves sleep by preventing the conscious processing of sensory stimuli. The Perturbational Complexity Index (PCIst) has recently been proposed as an objective measure of brain-responses complexity and well correlates with the level of consciousness, as assessed by subjective reports. Moreover, a growing body of evidence shows that, in adults, PCIst values are associated with different states of consciousness, with greater complexity during wakefulness than sleep (2). Previous developmental studies highlighted that the sleep-stage affects somatosensory-evoked potentials (SEPs), with larger SEPs in sleep than in wakefulness, already at birth (3). Here, we investigated the emergence of complexity of brain-responses, capitalizing on a recently devised approach, based on the computation of PCIst on the responses elicited by peripheral stimulations. EEG responses to median-nerve electrical stimulation during wakefulness and sleep were collected both in full-term healthy newborns (N=9; age=12-72 hours) and infants (N=9; age=3-4 months). In line with previous studies, in newborns' SEPs, the mean amplitude of middle- and long-latency components resulted greater in sleep than in wakefulness, in centroparietal (P1: $p=0.03$; $t=2.56$) and frontocentral (P2: $p=0.05$; $t=0.05$) clusters. Coherently, infants' results showed the same pattern in early- and late-latency SEPs components, in centroparietal (N1: $p=0.01$, $t=3.11$) and parietal (P2: $p=0.05$, $t=2.32$) clusters. Conversely, by comparing PCIst values, a diametrical pattern was found between the two samples. While newborns showed significantly higher PCIst values in sleep than in wakefulness ($p=0.004$; $t=3.95$), infants, similarly to adults, showed higher PCIst values in wakefulness than in sleep ($p=0.005$; $t=3.82$). Hence, while the ERPs pattern suggests greater response segregation during sleep already at birth, PCIst values may indicate that the functional architecture allowing the complexity to emerge during wakefulness fully develops only postnatally, within the first three months. Indeed, three-months old infants already show a pattern of brain-responses similar to that of adults, characterized by greater complexity during wakefulness than during sleep.

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