



Fig 2 | Participant after a normal night's sleep (left) and after sleep deprivation (right). Faces were presented in a counterbalanced order

in the association from 2.4 to 2.1 (SE 0.1; $P < 0.001$) with tiredness estimated at -0.56 (SE 0.1; $P < 0.001$).

DISCUSSION

Sleep deprived people are perceived as less attractive, less healthy, and more tired compared with when they are well rested. Apparent tiredness was strongly related to looking less healthy and less attractive, which was also supported by the mediating analyses, indicating that a large part of the found effects and relations on appearing healthy and attractive were mediated by looking tired. The fact that untrained observers detected the effects of sleep loss in others not only provides evidence for a perceptual ability not previously subjected to experimental control, but also supports the notion that sleep history gives rise to socially relevant signals that provide information about the bearer. The adaptiveness of an ability to detect sleep related facial cues resonates well with other research, showing that small deviations from the average sleep duration in the long term are associated with an increased risk of health problems and with a decreased longevity.^{8,17} Indeed, even a few hours of sleep deprivation inflict an array of physiological changes, including neural, endocrinological, immunological, and cellular functioning, that if sustained are relevant for long term health.^{7,18-20} Here, we show that such physiological changes are paralleled by detectable facial changes.

These results are related to photographs taken in an artificial setting and presented to the observers for only six seconds. It is likely that the effects reported here would be larger in real life person to person situations, when overt behaviour and interactions add further information. Blink interval and blink duration are known to be indicators of sleepiness,²¹ and trained observers are able to evaluate reliably the drowsiness of drivers by watching their videotaped faces.²² In addition, a few of the people were perceived as healthier, less tired, and more attractive during the sleep deprived condition. It remains to be evaluated in follow-up research whether this is due to random error noise in judgments, or associated with

specific characteristics of observers or the sleep deprived people they judge. Nevertheless, we believe that the present findings can be generalised to a wide variety of settings, but further studies will have to investigate the impact on clinical studies and other social situations.

Importantly, our findings suggest a prominent role of sleep history in several domains of interpersonal perception and judgment, in which sleep history has previously not been considered of importance, such as in clinical judgment. In addition, because attractiveness motivates sexual behaviour, collaboration, and superior treatment,¹³ sleep loss may have consequences in other social contexts. For example, it has been proposed that facial cues perceived as attractive are signals of good health and that this recognition has been selected evolutionarily to guide choice of mate and successful transmission of genes.¹³ The fact that good sleep supports a healthy look and poor sleep the reverse may be of particular relevance in the medical setting, where health estimates are an essential part. It is possible that people with sleep disturbances, clinical or otherwise, would be judged as more unhealthy, whereas those who have had an unusually good night's sleep may be perceived as rather healthy. Compared with the sleep deprivation used in the present investigation, further studies are needed to investigate the effects of less drastic acute reductions of sleep as well as long term clinical effects.

Conclusions

People are capable of detecting sleep loss related facial cues, and these cues modify judgments of another's health and attractiveness. These conclusions agree well with existing models describing a link between sleep and good health,^{18,23} as well as a link between attractiveness and health.¹³ Future studies should focus on the relevance of these facial cues in clinical settings. These could investigate whether clinicians are better than the average population at detecting sleep or health related facial cues, and whether patients

WHAT IS ALREADY KNOWN ON THIS TOPIC

Short or disturbed sleep and fatigue constitute major risk factors for health and safety
Complaints of short or disturbed sleep are common among patients seeking healthcare
The human face is the main source of information for social signalling

WHAT THIS STUDY ADDS

The facial cues of sleep deprived people are sufficient for others to judge them as more tired, less healthy, and less attractive, lending the first scientific support to the concept of “beauty sleep”

By affecting doctors' general perception of health, the sleep history of a patient may affect clinical decisions and diagnostic precision

with a clinical diagnosis exhibit more tiredness and are less healthy looking than healthy people. Perhaps the more successful doctors are those who pick up on these details and act accordingly.

Taken together, our results provide important insights into judgments about health and attractiveness that are reminiscent of the anecdotal wisdom harboured in Bell's words, and in the colloquial notion of “beauty sleep.”

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Data sharing: Statistical code and dataset of ratings are available from the corresponding author at john.axelsson@ki.se.

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