Why Later Bedtime Increases Health Risks

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Formulation of the problem. A recent study of school kids has shown that later bedtime increases health risks. How can we explain this observation?

Main idea behind our explanation. Our explanation is based on the following general result. If a final optimality criterion – i.e., criterion for which there is exactly one optimal alternative – is invariant with respect to some transformation g, then the corresponding optimal alternative a_{opt} is also invariant with respect to g, i.e., $g(a_{\text{opt}}) = a_{\text{opt}}$. In such situations, to find the optimal alternative, it is sufficient to search among all invariant alternatives.

Another fact that we will use is that if an alternative a is close to the optimal alternative, then its effectiveness is close to optimal, and $g(a)$ is close to a: $g(a) \approx a$. So, if we cannot find an invariant alternative, then at least we should look for alternatives that are close to invariant – i.e., for which $g(a) \approx a$.

What is a natural transformation here. In general, there is a lot of similarity between the starting and ending stages of a process, stages on which there is a reasonably slow transition between the two states. For example, there is a lot of similarity between the stage when a bus starts moving and the stage on which the bus slows down to a stop.

Similarly, in humans, there is similarity between processes related to waking up and processes related to going to bed. The corresponding transformation relates events that occur at moment Δt after waking up at moment t_w and the events at moment Δt before going to bed t_b, i.e., transforms the time $t = t_w + \Delta t$ into $g(t) = t_b - \Delta t$.

From the first formula, we get $\Delta t = t - t_w$. Substituting this expression into the second formula, we conclude that $g(t) = (t_w + t_b) - t$.

How this explains the observed phenomenon. According to the above general result, the optimal bedtime arrangement should be invariant – or at least as invariant as possible – with respect to the transformation $g(t)$. This means, in particular, that the time period from waking up to the first major meal of the day – which is breakfast – should be as close as possible to the time period from the last major meal of the day (dinner) to the bedtime.

Later bedtime usually means that the school kids wake up as close to the school start time as possible, with barely time to eat breakfast and leave. From this viewpoint, earlier wake up time – that allows some time before breakfast – is better for a student's health.

Some students who wake up later skip breakfast altogether. In this case, there is an even bigger discrepancy between the time from waking up to the first major meal – which in this case is lunch – and the time from dinner to going to bed.