Supplementary Information: Reported sleep duration reveals segmentation of the adult life-course into three phases

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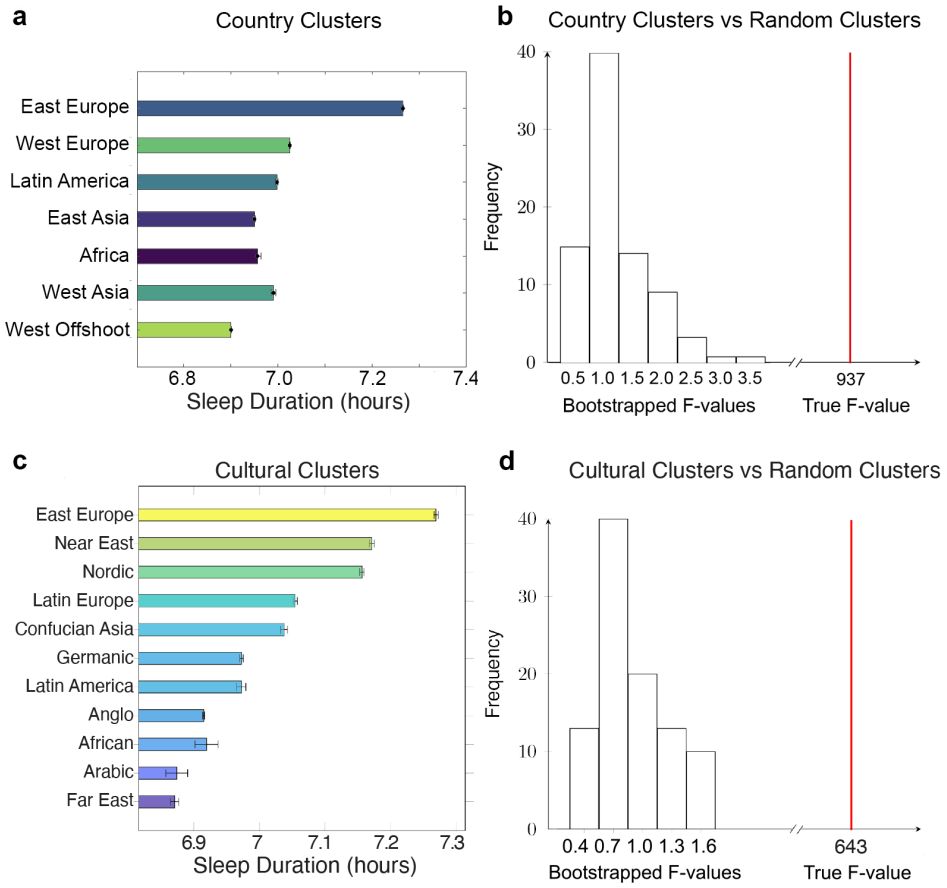
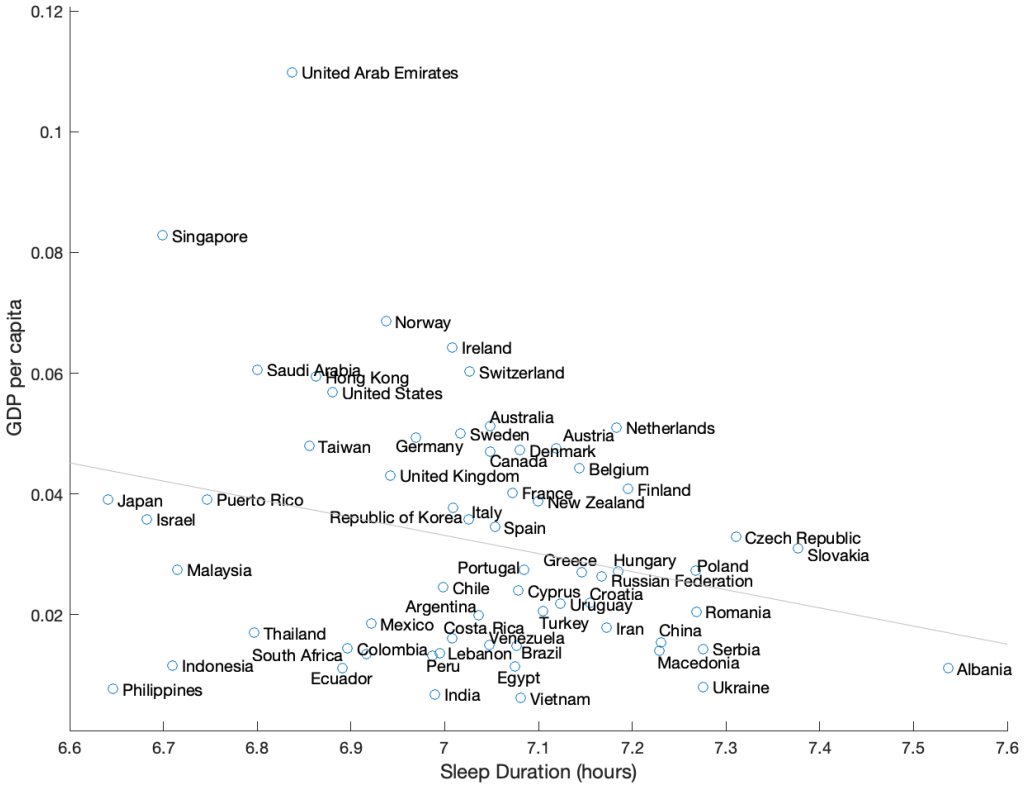
Supplementary Figures

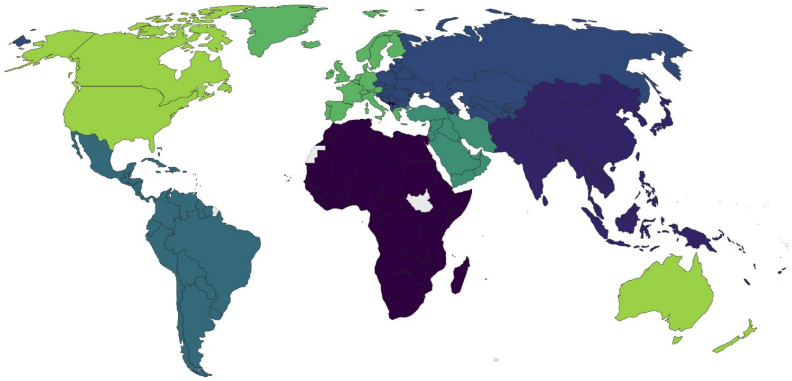


Supplementary Fig. 1: **Between-country sleep duration differences can be clustered into supra-national regions. a -** Average sleep duration in the 7 global clusters of countries defined in (*1*). These clusters are based on historical and economical proximity and constitute one of the most common world map segmentation [25]. The sample size and demographics of these clusters are available Fig. S3. Error bars correspond to 95% confidence intervals. **b -** We randomly shuffled the country labels 100 times. At each iteration, we computed the F-value from an ANOVA predicting the sleep durations from the age, gender, and global clusters based on the random country labels. We show the histogram of the bootstrapped random global clusters F-values (M=0.95, 95%CI=[0.84 1.06]) and the true F-value corresponding to the actual global clusters (vertical red line, F(6, 730181)=936.97), far above the largest random F-value. **c-d -** We repeated this analysis with a slightly different set of clusters, based on cultural similarities between countries (*2*) and obtained similar results.



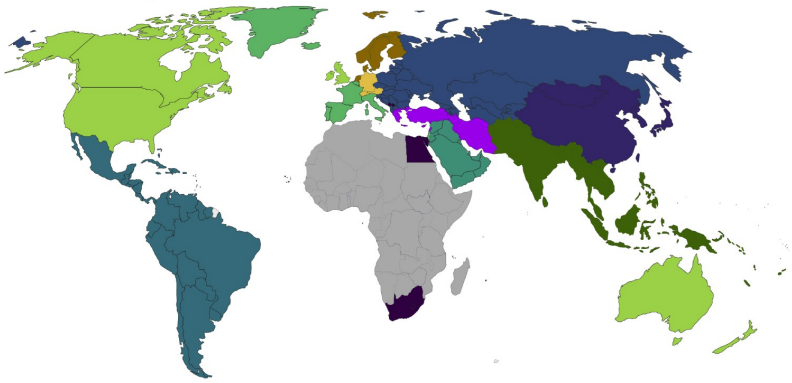
Supplementary Fig. 2: **Association between country-level average sleep duration and Gross Domestic Product per capita.** A linear regression with sleep duration as the response variable gives significant effects for both GDP per capita (t(60) = -4.57, $p < 0.001$) and latitude (t(60) = 6.59, $p < 0.001$). We computed the same regression with the countries' conditional modes (country-level deviation from the population-level average predicted sleep duration corrected for the other demographics) as predictors, and also found a significant effect of both GDP per capita (t(60) = -2.37, p = 0.02) and latitude (t(60) = 3.38, p = 0.001)).

a - Country clusters defined in Maddison (2010), based on historical and economic proximity



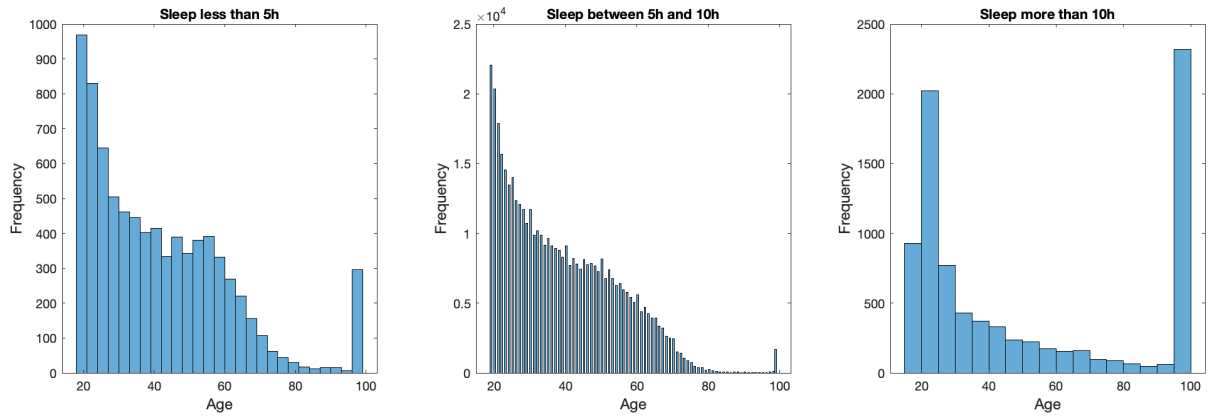
Country Cluster	N	Males	Age ($M \pm SD$)	Sleep Duration ($M \pm SD$)
East Europe	77296	43312	30.96 (±11.04)	7.26 (±1.16)
West Europe	342692	185087	40.39 (±14.25)	7.02 (±1.01)
Latin America	36219	20909	33.65 (±13.29)	6.99 (±1.13)
East Asia	38005	22879	29.60 (±10.20)	6.95 (±1.08)
Africa	2763	1675	37.12 (±14.38)	6.95 (±1.12)
West Asia	8771	5987	33.16 (±11.13)	6.99 (±1.15)
West Offshoot	224441	101304	41.39 (±15.15)	6.90 (±1.05)

b - Country clusters defined in Ronen & Shenkar (2013), based on cultural proximity

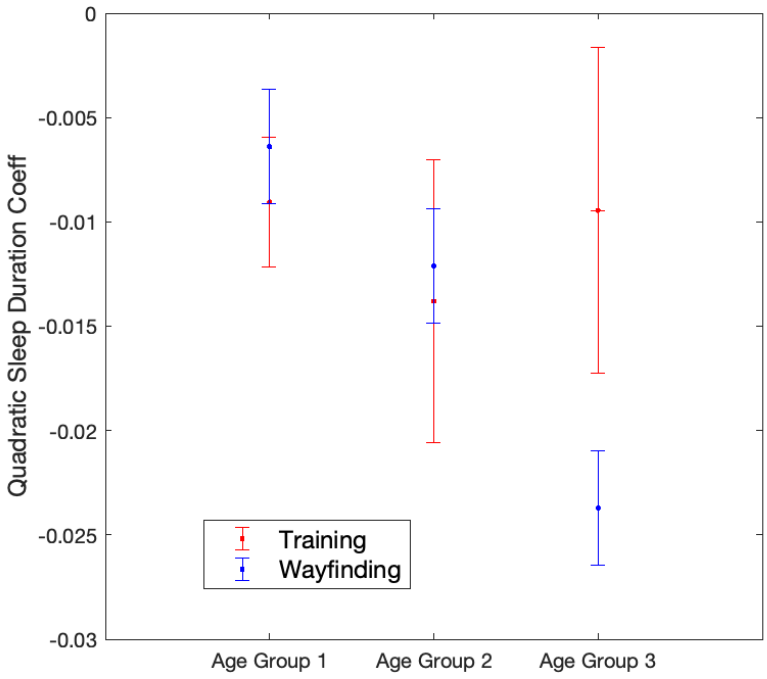


Cultural Cluster	N	Males	Age ($M \pm SD$)	Sleep Duration ($M \pm SD$)
East Europe	77296	43312	30.96 (±11.04)	7.26 (±1.16)
Near East	46584	27888	34.05 (±11.19)	7.14 (±1.16)
Nordic	51742	24310	38.00 (±14.04)	7.15 (±0.99)
Latin Europe	59642	34851	37.28 (±13.93)	7.04 (±1.00)
Confucian Asia	21205	11165	30.57 (±10.20)	7.03 (±1.01)
Latin America	36219	20909	33.65 (±13.29)	6.99 (±1.13)
Germanic	71762	38587	42.39 (±13.90)	6.97 (±0.98)
Anglo	343869	165154	42.24(±14.95)	6.91 (±1.03)
African	2763	1675	37.12 (±14.38)	6.95 (±1.12)
Arabic	2305	1588	34.01 (±11.35)	6.81 (±1.19)
Far East	16800	11714	28.37 (±10.07)	6.83 (±1.15)

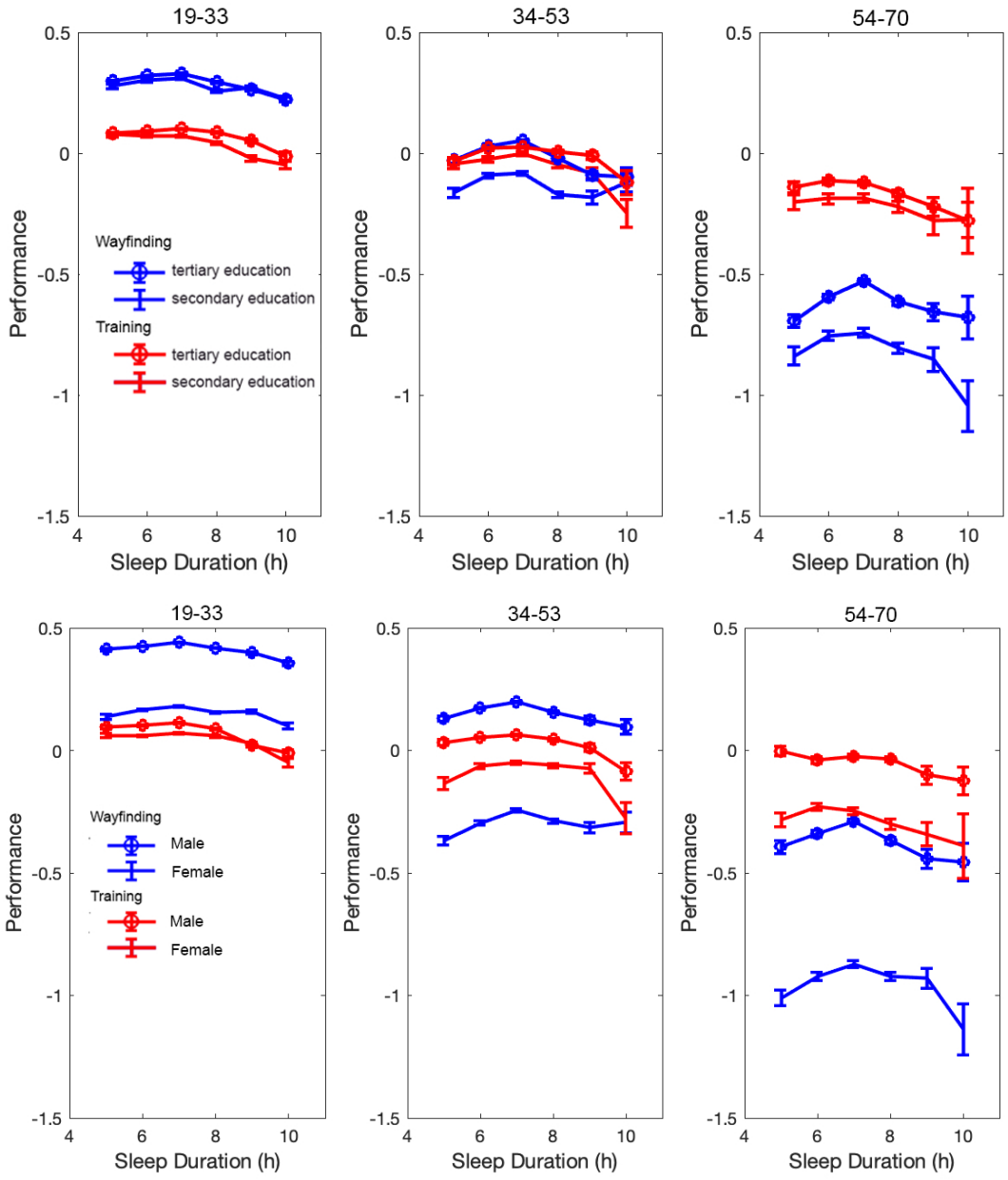
Supplementary Fig. 3: **a -** Demographics of the supra-national clusters defined in (*1*). **b -** Demographics of the supra-national clusters defined in (*2*).



Supplementary Fig. 4: Age distribution of participants who reported sleeping less than 5h, between 5h and 10h, more than 10h.



Supplementary Fig. 5: Quadratic sleep duration coefficients from 3 ANOVAs independently computed for each age group identified in Fig. 1, with Wayfinding Performance and Training Performance as the response variable. The structure of the tested models is 'performance $\sim$ sleepduration + sleepduration^2 + education + home environment + commute duration'. Error bars correspond to 95% confidence intervals.



Supplementary Fig. 6: **Association between reported sleep duration and spatial ability in the 3 age groups identified in Fig. 1, stratified by level of education (top) and gender (bottom).** Spatial ability was quantified with the Sea Hero Quest (SHQ) wayfinding task. Training levels did not require spatial ability as the target was visible from the starting point. In the first, second and third age groups, the sample sizes are respectively n = 321,406, n = 263,932 and n = 144,849. Error bars correspond to standard errors, their centers correspond to the mean performance for a given sleep duration.

Supplementary Tables

Table S1 - Country-level Characteristics.

Country	2L	isWEIRD	Mean Sleep (h)	Means Sleep Under 40 (h)	GDP per Capita	Mean Latitude	Sample Size
United Arab Emirates	AE	0	6.84	6.8769	0.10987	24.2578	1376
Albania	AL	0	7.5367	7.5484	0.011122	41.0911	941
Argentina	AR	0	7.0364	7.0955	0.019854	-37.667	3684
Austria	AT	1	7.1185	7.2132	0.047587	47.5748	3477
Australia	AU	1	7.0488	7.1427	0.051178	-25.2184	16134
Belgium	BE	1	7.1437	7.197	0.044259	50.5956	3869
Brazil	BR	0	7.0766	7.0914	0.014859	-9.8028	14089
Canada	CA	1	7.0485	7.0667	0.046991	65.2941	21732
Switzerland	CH	1	7.0269	7.0721	0.060258	46.7416	5880
Chile	CL	0	6.9982	7.0266	0.024515	-44.8384	3269
China	CN	0	7.2304	7.2549	0.015327	35.3034	11482
Colombia	CO	0	6.8962	6.9316	0.014424	3.4711	2735
Costa Rica	CR	0	7.0079	7.0013	0.016076	9.7459	1133
Cyprus	CY	0	7.0784	7.2241	0.023953	34.9549	523
Czech Republic	CZ	0	7.3105	7.3726	0.032872	49.8784	24423
Germany	DE	1	6.9695	7.0495	0.049371	51.1662	64569
Denmark	DK	1	7.0804	7.131	0.047236	55.7047	3046
Ecuador	EC	0	6.8912	6.919	0.011196	-1.6431	726
Egypt	EG	0	7.0745	7.1297	0.011387	27.6394	738
Spain	ES	1	7.0534	7.1738	0.034519	38.5314	14542
Finland	FI	1	7.1953	7.191	0.040817	64.3201	1157
France	FR	1	7.0726	7.1506	0.04022	35.085	15257
United Kingdom	GB	1	6.9418	7.0581	0.043045	55.5618	121983
Greece	GR	0	7.1465	7.2571	0.026977	38.3598	41247
Hong Kong	HK	0	6.8631	6.8773	0.059431	22.3726	2031
Croatia	HR	0	7.1551	7.2893	0.021957	44.64	1283
Hungary	HU	0	7.1846	7.2519	0.027165	47.2323	16504
Indonesia	ID	0	6.7095	6.7173	0.01162	-2.9963	2200
Ireland	IE	1	7.0078	7.098	0.064257	53.4979	2708
Israel	IL	0	6.6822	6.7487	0.035784	31.8831	925
India	IN	0	6.9893	7.014	0.006803	23.3842	6551
Iran	IR	0	7.1723	7.2302	0.017788	33.2924	1764
Italy	IT	1	7.0259	7.1645	0.035743	42.1826	21976
Japan	JP	0	6.6409	6.7361	0.039003	35.4739	621
Republic of Korea	KR	0	7.0085	6.9966	0.03769	35.7337	1059
Lebanon	LB	0	6.9947	7.1158	0.01367	33.8606	566
Macedonia	MK	0	7.2292	7.3264	0.014032	41.6354	637
Mexico	MX	0	6.9214	6.9523	0.018519	24.2179	7954
Malaysia	MY	0	6.7151	6.7366	0.0275	3.9696	2355
Netherlands	NL	1	7.1834	7.2956	0.05097	48.2584	43215
Norway	NO	1	6.9372	7.0079	0.068552	69.8766	1989
New Zealand	NZ	1	7.0998	7.2005	0.038756	-40.8627	3305
Peru	PE	0	6.9864	7.0141	0.013223	-7.4457	959
Philippines	PH	0	6.6462	6.6644	0.0076916	11.4573	3050
Poland	PL	0	7.268	7.308	0.027342	51.4007	14602
Puerto Rico	PR	0	6.7466	6.7561	0.039083	18.1731	959
Portugal	PT	1	7.0848	7.1409	0.027409	39.2181	4349
Romania	RO	0	7.2682	7.3014	0.020483	45.8446	5247
Serbia	RS	0	7.2757	7.3569	0.014316	44.2476	602
Russian Federation	RU	0	7.1676	7.1705	0.026325	63.3803	5067
Saudi Arabia	SA	0	6.8002	6.8428	0.060584	23.1493	961
Sweden	SE	1	7.017	7.1119	0.050008	61.8845	3241
Singapore	SG	0	6.6994	6.718	0.08285	1.3664	2828
Slovakia	SK	0	7.3768	7.4392	0.030996	48.8382	7012
Thailand	TH	0	6.7971	6.7627	0.01697	13.2487	1700
Turkey	TR	0	7.1049	7.1264	0.020657	39.0661	3288
Taiwan	TW	0	6.8553	6.88	0.04794	23.7266	3310
Ukraine	UA	0	7.2754	7.2852	0.0080075	48.7207	1180
United States	US	1	6.8808	6.8887	0.056823	48.7409	193210
Uruguay	UY	0	7.1237	7.1567	0.0218	-32.2973	582
Venezuela	VE	0	7.0478	7.1511	0.014969	7.3982	753
Vietnam	VN	0	7.0814	7.0876	0.0061866	16.5251	1081
South Africa	ZA	0	6.9165	6.97	0.013477	-28.8461	2133

Table. S 1: Demographics of the 63 countries included in the analysis.

Fixed Effects	Estimate (95% CI)	Standard Error	t-value	p-value
Intercept	8.44 (8.39 8.49)	0.026	323.88	< 0.001
Age	-0.060 (-0.061 -0.059)	6.0×10^{-4}	-98.95	< 0.001
Age^2	6.1×10^{-4} (6.0 6.2)10^{-4}	6.6×10^{-6}	92.80	< 0.001
Gender	-0.18 (-0.19 -0.17)	6.9×10^{-3}	-26.00	< 0.001
Commute	-0.29 (-0.31 -0.27)	9.2×10^{-3}	-31.32	< 0.001
Education	0.19 (0.18 0.21)	7.9×10^{-3}	25.00	< 0.001
Home Environment	-0.063 (-0.078 -0.049)	7.7×10^{-3}	-8.15	< 0.001
Age*Gender	1.6×10^{-3} (1.3 1.9)10^{-3}	1.7×10^{-4}	9.55	< 0.001
Age*Commute	1.5×10^{-3} (1.1 2.0)10^{-3}	2.3×10^{-4}	6.72	< 0.001
Age*Education	-4.9×10^{-3} (-5.2 -4.5)10^{-3}	1.8×10^{-4}	-26.55	< 0.001
Age*Home Environment	2.2×10^{-3} (1.8 2.6)10^{-3}	1.9×10^{-4}	11.84	< 0.001
Random Effect	**Std (95% CI)**	**VPC (95% CI)**		
Country (intercept)	0.17 (0.16 0.21)	2.75% (2.02 3.81)		
Error (intercept)	1.04 (1.03 1.04)			
sample size = 729,948, 63 countries				

Table. S 2: Output of the linear mixed model calculated to predict sleep duration with age, age^2, gender, education, home environment, commute duration and their interaction with age as fixed effects, and random intercepts clustered by countries: sleep duration $\sim$ age*(gender + education + home environment + commute duration) + age^2 + (1 | country).

	Wayfinding Performance		Training Performance	
Variable	F-value	p-value	F-value	p-value
Intercept	451.86	< 0.001	58.08	< 0.001
Gender	19918	< 0.001	1161.90	< 0.001
SleepDuration	186.16	< 0.001	41.45	< 0.001
SleepDuration^2	193.97	< 0.001	49.58	< 0.001
AgeGroups	136.32	< 0.001	6.03	0.002
Commute	11.73	< 0.001	3.97	0.02
Education	961.01	< 0.001	166.26	< 0.001
Home Environment	1452.5	< 0.001	178.88	< 0.001
AgeGroups*SleepDuration	49.56	< 0.001	2.40	0.09
AgeGroups*SleepDuration^2	55.05	< 0.001	3.19	0.04
sample size = 418,152				

Table. S 3: Output of two ANOVAs calculated to predict wayfinding and training performance with sleepduration, sleepduration^2 and their interaction with age groups, gender, education, home environment, commute duration as independent variables: performance $\sim$ age-groups*(sleepduration +sleepduration^2) + education + home environment + commute duration. The 3 age groups are the ones identified in Fig 1C: younger (19-33 y.o., N=191,791), middle (34-53 y.o., N=153,884), and older (54-70 y.o., N=72,477) participants.

Supplementary References

1. A. Maddison, *The world economy*. OECD publishing, 2006.

2. S. Ronen and O. Shenkar, "Mapping world cultures: Cluster formation, sources and implications," *Journal of International Business Studies*, vol. 44, no. 9, pp. 867–897, 2013.