Supplementary Methods

EEG source analysis

Head and forward models

For each recording session and participant, electrode positions were measured with a Polhemus FASTRAK system (Polhemus Inc.). We aligned the electrode locations to the standardized electrode positions from the standard_1020.elc template in MNI space and projected them onto scalp surface according to FieldTrip procedures. Leadfields were constructed to define the mapping from an 8 mm resolution grid for source activities to EEG scalp electrodes based on a standardized 3-layer boundary element model of the Colin27 brain[1] separately for each recording session.

EEG source localization

EEG data were lowpass filtered to 28 Hz and downsampled to 64 Hz. For each recording session and participant, pre-stimulus EEG from -0.6 to -0.1 s from all conditions and post-stimulus data from 0.1 to 0.3 s from unisensory 1-flash and 2-flash trials (to focus on visual activity) were concatenated. We computed the corresponding covariance matrix and the spatial filter coefficients of the linearly constrained minimum variance (LCMV) beamformer[2] as implemented in the FieldTrip toolbox[3] (with regularization parameter lambda = '5%').

We projected the 28 Hz lowpass-filtered EEG signal of each trial (-1.2 to 0.7 s) into source space through these spatial filters. The dimensionality of the 3-coordinate spatial filters was reduced to a single orientation that maximizes the filter output (FieldTrip parameter fixedori = true).

ROI definition

We defined our region of interest in source space by combining anatomical and functional constraints. First, our regions of interest were constrained to V1v, V1d, V2v, V2d, V3v, V3d, hV4, VO1, VO2, PHC1, PHC2, MST, hMT, LO2, LO1, V3a, V3b in the right hemisphere (i.e. contralateral to the flash) based on functional probabilistic maps[4]. Second, we included grid points with significant ($p<0.05$ uncorrected) 'post-stimulus source power' as defined by the following contrast (see Supplementary Figure 7 for post-stimulus source power overlaid on brain sections):

$$\text{poststimulus source power} = \frac{Var_{post\,[100ms,300\,ms]} - Var_{pre[-600ms,-100\,ms]}}{Var_{pre[-600ms,-100\,ms]}}$$

Within this mask, we included the 5% voxels with the greatest post-stimulus power and identified the brain source grid points that were within 1 cm distance from the geometric mean of this ROI. This procedure yielded seven grid points as our final ROI.

Extraction of source activity from ROI and Alpha frequency analysis

We extracted the source activity for each trial from -0.6 to 0.3 s from those seven grid points. In Supplementary Figure 7, we show the timecourse of the first eigenvariate across time and sessions (averaged across trials and participants) together with the grand average pooled over O2, PO4, PO8. Because the sign of the first eigenvariate of source activity is not meaningful, we used the sign for each participant that minimized the mean square error with respect to the grand average across electrodes. As shown in the figure, the timecourses of source and sensor activity are well in correspondence, which validates our source analysis and ROI definition. For the 7 grid points in the ROI, we extracted the source activity for each trial from -1.2 to 0.7 s and performed the frequency sliding (within subject) analysis and individual alpha peak estimation (between subject) using the methodological procedures as described for the sensor analysis in the main paper.

Supplementary Results

Within-participant results in source space: Effects of alpha frequency on *d'* and $Bias_{centre}$

We repeated our analyses in source space to focus on alpha sources in occipital cortices (Supplementary methods 1, Supplementary Figures 2 and 3, Supplementary Tables 10-12). Out of these 30 tests, two were significant in the source space analysis. In the time-collapsed analysis, we observed a significant effect of alpha frequency on *d'* both for t-test p-values and Bayes factors. However, the effect was in the opposite direction than predicted by the alpha temporal resolution hypothesis with greater *d'* for lower alpha frequency (0 sound condition, time collapsed: t_{20} = 3.286, p = 0.004, d = 0.270, 95% CI = [0.092, 0.416], BF = 11.357). Moreover, this effect was observed only for the 'yes-no SOA', but not for the 'yes-no threshold' experiment. Further, in the time-resolved analysis, we observed a brief effect in the expected direction in the 'yes-no' experiment for the 1 sound condition (time resolved: p = 0.015). But this effect was again not replicated in the 'yes-no threshold' experiment (Supplementary Figure 2, Supplementary Table 10). We did not observe any effect of pre-stimulus alpha frequency on bias. Further, the effects did not correlate between the two experiments across participants.

The effect of alpha frequency at high and low pre-stimulus alpha power

We also assessed whether effects of alpha frequency may depend on alpha power. Hence, we repeated the time-collapsed frequency analysis separately for low and high alpha power trials. There was no significant alpha frequency effect on *d'* for high or low alpha power with most tests showing substantial evidence for the null hypothesis (Supplementary Table 8). We observed two significant alpha frequency effects on $Bias_{centre}$ in the low power group for the 'yes-no' 0-sound (t_{20} = -3.729, p = 0.001, d = 0.287, 95% CI = [-0.275, -0.077]) and 2-sound (t_{20} = 2.897, p = 0.009, d = 0.160, 95% CI = [0.036, 0.225]) conditions. However, both effects were opposite to the direction of the alpha temporal resolution hypothesis (Supplementary Table 9).

The effect of pre-stimulus alpha power on *d'* and $Bias_{centre}$

Because alpha frequency and power are intimately related[5,6], we also assessed the role of pre-stimulus alpha power on *d'* and $Bias_{centre}$. Pre-stimulus alpha power did not significantly affect perceptual sensitivity in any of the sensory contexts. We observed a significantly stronger bias for low relative to high alpha power in the 'one sound' context of the 'yes-no threshold' experiment (Supplementary Figure 6).

Comparing pre-stimulus alpha frequency for one and two flash perceptual outcomes

Following previous work[7] we also directly compared pre-stimulus alpha frequency for trials with 'one flash' and 'two flash' perceptual outcomes (Supplementary Figure 5). Again, this analysis did not reveal any significant effects.

Supplementary Tables

Behavioural analyses

Supplementary Table 1. Number of trials for within subject analyses of sensitivity and bias.

		0 sounds	1 sound	2 sounds
Yes-no SOA				
	1 flash	599.5 ± 15.87 *SEM*	613.5 ± 17.35 *SEM*	306.7 ± 8.578 *SEM*
	2 flashes	297.45 ± 8.19 *SEM*	304.85 ± 8.925 *SEM*	308 ± 8.535 *SEM*
Yes-no threshold				
	1 flash	456.7 ± 14.994 *SEM*	461.45 ± 14.4 *SEM*	460.8 ± 14.12 *SEM*
	2 flashes	461.65 ± 14.457 *SEM*	464.05 ± 14.619 *SEM*	463.9 ± 15.063 *SEM*

SEM, standard error of the mean

Supplementary Table 2. **Behavioral performance accuracy in the ‘yes-no SOA’ and ‘yes-no threshold’ experiments for none, one and two sound contexts.**

		0 sounds	1 sound	2 sounds
Yes-no SOA				
	1 flash	0.91 ± 0.02 *SEM*	0.96 ± 0.01 *SEM*	0.50 ± 0.07 *SEM*
	2 flashes	0.63 ± 0.05 *SEM*	0.52 ± 0.05 *SEM*	0.84 ± 0.04 *SEM*
Yes-no threshold				
	1 flash	0.85 ± 0.03 *SEM*	0.92 ± 0.02 *SEM*	0.48 ± 0.06 *SEM*
	2 flashes	0.45 ± 0.04 *SEM*	0.44 ± 0.04 *SEM*	0.81 ± 0.05 *SEM*

SEM, standard error of the mean

Supplementary Table 3. Statistical comparisons of *d’* and $Bias_{centre}$ between auditory contexts in the ‘yes-no SOA’ experiment for intermediate SOAs (cf. Figure 1c).

	0 vs 1 sound			0 vs 2 sounds			1 vs 2 sounds		
	N	**t**	**d**	**N**	**t**	**d**	**N**	**t**	**d**
d’	20	-1.667	-0.124	20	3.796**	0.707	20	4.528***	0.789
$Bias_{centre}$	20	-5.193***	-0.781	20	10.240***	1.771	20	12.831***	2.234

d, Cohen’s d. t, t-value. $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***).

Supplementary Table 4. Pairwise correlations of perceptual threshold estimates between experiments (cf. Supplementary Figure 7).

	0 sounds			**1 sound**			**2 sounds**		
	N	**r**	**BF**	**N**	**r**	**BF**	**N**	**r**	**BF**
2IFC vs Yes-no SOA	20	0.592	7.259*[A]	19	0.802	785.368*[A]	19	0.501	1.869
2IFC vs Yes-no threshold	20	0.514	2.450	19	0.713	57.949	20	-0.379	0.661
Yes-no SOA vs Yes-no threshold	20	0.823	2909.023*[A]	20	0.874	42365.344*[A]	19	0.199	0.243*[0]

N, number of participants; r, Pearson correlation; BF, Bayes factor; BF < 1/3 (*[0]), BF > 3 (*[A]).

Within subject alpha frequency analyses in <u>sensor space</u>

Supplementary Table 5. Sensor level analysis: Statistical comparison of *d'* for low vs. high alpha frequency (time-collapsed, cf. Figure 2a).

	0 sounds			1 sound			2 sounds		
	N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
Yes-no SOA	20	1.057	0.380	20	1.012	0.365	20	1.471	0.588
Yes-no threshold	20	0.106	0.234*^{0}	20	1.341	0.506	20	-0.106	0.234*^{0}

N, number of participants; t, t-value; BF, Bayes factor; BF < 1/3 (*^{0}). Positive t-values indicate a larger *d'* for low relative to high alpha frequency.

Supplementary Table 6. Sensor level analysis: Statistical comparison of $Bias_{centre}$ for low vs. high alpha frequency (time-collapsed, cf. Figure 3a).

	0 sounds			1 sound			2 sounds		
	N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
Yes-no SOA	20	-1.151	0.415	20	0.237	0.238*^{0}	20	0.610	0.275*^{0}
Yes-no threshold	20	-0.944	0.345	20	0.235	0.238*^{0}	20	1.705	0.793

N, number of participants; t, t-value; BF, Bayes factor; BF < 1/3 (*^{0}). Positive t-values indicate a larger $Bias_{centre}$ for low relative to high alpha frequency.

Supplementary Table 7. Sensor level analysis: Consistency of alpha frequency effects across experiments for *d'* and $Bias_{centre}$ (time-collapsed, cf. Figure 2b, Figure 3b).

	0 sounds			1 sound			2 sounds		
	N	**r**	**BF**	**N**	**r**	**BF**	**N**	**r**	**BF**
d'	20	-0.219	0.262*^{0}	20	0.067	0.177*^{0}	20	-0.098	0.186*^{0}
$Bias_{centre}$	20	0.319	0.435	20	0.569**	5.102*^{A}	20	0.529*	2.973

N, number of participants; r, Pearson's correlation coefficient; $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***); BF, Bayes factor; BF < 1/3 (*^{0}), BF > 3 (*^{A}).

Supplementary Table 8. Sensor level analysis: Statistical comparison of *d'* for pre-stimulus low and high alpha frequency (time-collapsed), separately for low and high alpha power trials (time-collapsed analysis).

		0 sounds			1 sound			2 sounds		
		N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
High power	Yes-no SOA	20	-0.174	0.235*[0]	20	0.457	0.255*[0]	20	0.216	0.237*[0]
	Yes-no threshold	20	1.817	0.924	20	-0.564	0.268*[0]	20	0.265	0.240*[0]
Low power	Yes-no SOA	20	-0.903	0.334	20	-2.249*	1.778	20	0.444	0.254*[0]
	Yes-no threshold	20	-0.270	0.240*[0]	20	-0.860	0.323*[0]	20	-0.044	0.233*[0]

N, number of participants; t, t-value; $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***); BF, Bayes factor; BF < 1/3 (*[0]). Positive t-values indicate a larger *d'* for low relative to high alpha frequency.

Supplementary Table 9. Sensor level analysis: Statistical comparison of $Bias_{centre}$ for pre-stimulus low and high alpha frequency (time-collapsed), separately for low and high alpha power trials (median split).

		0 sounds			1 sound			2 sounds		
		N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
High power	Yes-no SOA	20	1.200	0.435	20	0.057	0.233*	20	-0.469	0.257*[0]
	Yes-no threshold	20	0.241	0.239*[0]	20	-1.337	0.504	20	-1.535	0.636
Low power	Yes-no SOA	20	-3.729**	26.910*[A]	20	-0.453	0.255*	20	2.897**	5.471*[A]
	Yes-no threshold	20	-1.466	0.585	20	-1.668	0.754	20	-1.304	0.486

N, number of participants; t, t-value; $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***); BF, Bayes factor; BF < 1/3 (*[0]), BF > 3 (*[A]). A positive t-value indicates a larger $Bias_{centre}$ for low relative to high alpha frequency.

Within subject alpha frequency analyses in <u>source space</u>

Supplementary Table 10. Source level analysis: Statistical comparison of *d'* for low vs. high alpha frequency (time-collapsed, cf. Supplementary Figure 2a).

	0 sounds			1 sound			2 sounds		
	N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
Yes-no SOA	20	3.286**	11.357*^{A}	20	-1.450	0.574	20	0.317	0.243*^{0}
Yes-no threshold	20	1.163	0.420	20	-0.942	0.344	20	0.968	0.352

N, number of participants; t, t-value; $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***); BF, Bayes factor; BF < 1/3 (*^{0}), BF > 3 (*^{A}). Positive t-values indicate a larger *d'* for low relative to high alpha frequency.

Supplementary Table 11. Source level analysis: Statistical comparison of $Bias_{centre}$ for low vs. high alpha frequency (time-collapsed, cf. Supplementary Figure 3a).

	0 sounds			1 sound			2 sounds		
	N	**t**	**BF**	**N**	**t**	**BF**	**N**	**t**	**BF**
Yes-no SOA	20	-0.123	0.234*^{0}	20	0.098	0.233*^{0}	20	0.819	0.313*^{0}
Yes-no threshold	20	1.371	0.524	20	-0.026	0.232*^{0}	20	-0.727	0.294*^{0}

N, number of participants; t, t-value; BF, Bayes factor; BF < 1/3 (*^{0}). Positive t-values indicate a larger $Bias_{centre}$ for low relative to high alpha frequency.

Supplementary Table 12. Source level analysis: Consistency of alpha frequency effects across experiments for *d'* and $Bias_{centre}$ (time-collapsed, cf. Supplementary Figures 2b, 3b).

	0 sounds			1 sound			2 sounds		
	N	**r**	**BF**	**N**	**r**	**BF**	**N**	**r**	**BF**
d'	20	0.311	0.414	20	0.236	0.281*^{0}	20	0.267	0.327*^{0}
$Bias_{centre}$	20	0.348	0.524	20	0.465	1.423	20	0.134	0.200*^{0}

N, number of participants; r, Pearson's correlation coefficient; BF, Bayes factor; BF < 1/3 (*^{0}).

Between subject alpha frequency analyses in <u>sensor space</u>

Supplementary Table 13. Sensor level analysis: Correlation between trait alpha peak frequency and perceptual window size

Threshold definition	Eyes-closed sensor level			Pre-stimulus sensor level		
2IFC	**N**	**r**	**BF**	**N**	**r**	**BF**
1F & 2F	20	0.22	0.26*^{0}	20	0.31	0.41
1F1S & 2F1S	19	-0.14	0.21*^{0}	19	-0.08	0.19*^{0}
1F2S & 2F2S	20	0.20	0.24*^{0}	20	0.17	0.22*^{0}
Yes-no SOA						
1F & 2F	20	-0.31	0.42	20	-0.19	0.24*^{0}
1F1S & 2F1S	20	-0.25	0.29*^{0}	20	-0.13	0.20*^{0}
1F2S & 2F2S	19	0.002	0.17*^{0}	19	0.20	0.24*^{0}
Staircase SOA						
2F	20	-0.16	0.21*^{0}	20	-0.21	0.25*^{0}
2F1S	20	-0.08	0.18*^{0}	20	-0.17	0.22*^{0}
1F2S	20	-0.33	0.46	20	-0.13	0.20*^{0}

N, number of participants; r, Pearson's correlation coefficient; BF, Bayes factor; BF < 1/3 (*^{0}).

Supplementary Table 14. Sensor level analysis for electrodes contralateral to flash stimulus: Correlation between trait alpha peak frequency and perceptual window size (i.e. threshold).

Threshold definition	Pre-stimulus sensor level			Eyes-closed sensor level		
2IFC	**N**	**r**	**BF**	**N**	**r**	**BF**
1F & 2F	20	0.264	0.321*^{0}	20	0.123	0.195*^{0}
1F1S & 2F1S	19	-0.014	0.175*^{0}	19	-0.128	0.200*^{0}
1F2S & 2F2S	20	0.097	0.185*^{0}	20	0.195	0.239*^{0}
Yes-no SOA						
1F & 2F	20	-0.155	0.211*^{0}	20	-0.453	1.255
1F1S & 2F1S	20	-0.138	0.202*^{0}	20	-0.355	0.553
1F2S & 2F2S	19	0.084	0.185*^{0}	19	0.051	0.178*^{0}
Staircase SOA						
2F	20	-0.090	0.183*^{0}	20	-0.226	0.269*^{0}
2F1S	20	-0.090	0.183*^{0}	20	-0.158	0.213*^{0}
1F2S	20	-0.068	0.178*^{0}	20	-0.278	0.344

N, number of participants; r, Pearson's correlation coefficient; BF, Bayes factor; BF < 1/3 (*^{0}).

Between subject alpha frequency analyses in <u>source space</u>

Supplementary Table 15. Source level analysis: Correlation between trait alpha peak frequency and perceptual window size (cf. Supplementary Figure 4).

Threshold definition	**Source level**		
2IFC	**N**	**r**	**BF**
1F & 2F	18	-0.31	0.40
1F1S & 2F1S	17	-0.31	0.39
1F2S & 2F2S	18	0.04	0.18*[0]
Yes-no SOA			
1F & 2F	18	-0.41	0.77
1F1S & 2F1S	18	-0.39	0.65
1F2S & 2F2S	17	-0.09	0.19*[0]
Staircase SOA			
2F	18	-0.10	0.19*[0]
2F1S	18	-0.23	0.27*[0]
1F2S	18	-0.04	0.18*[0]

N, number of participants; r, Pearson's correlation coefficient; BF, Bayes factor; BF < 1/3 (*[0]).

Supplementary References

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