Supplemental Material 3: Preprocessed Effect Sizes from Invididual Source Data

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I. Statement

All studies that provided processed individual sleep and memory measurement data by authors have undergone preprocessing or reanalysis to estimate correlation coefficients using standardized measurement methods selected for the meta-analysis. We are unable to disclose the source data due to copyright restrictions associated with the original studies. Instead, we will directly report the preprocessed effect sizes and formulas used. Individuals or groups who are interested in any source dataset should contact the authors of the original studies directly.

In cases where meta-analysis authors reached out to the original study authors via email to obtain effect sizes, if the original study authors chose to provide processed individual datasets rather than reporting effect sizes directly, neither party requested or exchanged any information that could potentially expose the personal identities of individual participants. The data may have been sorted, merged or excluded based on the methods outlined in the original studies and the moderator selection in the meta-analysis. All data processing was performed within the Quarto document of R Studio version 2023.6.1.524 (Posit Team, 2023) using the R language (R Core Team, 2022) Not all effect sizes reported in this material will necessarily be used in the meta-analysis, contingent upon the inclusion criteria and moderators.

II. Formulas

Pearson Product-Moment Correlation Coefficient

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{1}$$

Circular-Linear Correlation Coefficient

$$R = \sqrt{\frac{r_{12}^2 + r_{13}^2 + 2 \cdot r_{12} \cdot r_{13} \cdot r_{23}}{1 - r_{23}^2}} \tag{2}$$

where

$$r_{12} = \text{corr}(x, \cos\theta),\ r_{13} = \text{corr}(x, \sin\theta),\ \text{and}\ r_{23} = \text{corr}(\cos\theta, \sin\theta)$$

corr function refers to the Pearson's r formula in (1) (Mardia, 1976)

Declarative Memory Retention Rate

$$MRR(\%) = \frac{Recall_{\text{post.sleep}}}{Recall_{\text{pre.sleep}}} \times 100\% \tag{3}$$

III. Effect Sizes

Schreiner2021

Table 1: Schreiner 2021 Coupling and Memory Correlation Table (WIP)

Phase.Circlin.R	Phase.R.squared	Amplitude	Strength	SPcSO	SOcSP
0.5152	0.2654	0.1685	0.1275	0.0251	-0.1166

Table 2: Schreiner 2021 Coupling and Memory Correlation Table (TMR)

Phase.Circlin.R	Phase.R.squared	Amplitude	Strength	SPcSO	SOcSP
0.3868	0.1496	-0.2115	0.1638	-0.1982	-0.3942

Denis2021a

Table 3: Denis 2021 (TMR) CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
N2 Neutral	0.2393	0.0572
N2 Emotional	0.2107	0.0444
N2 Weighted	0.2282	0.0521
N3 Neutral	0.1469	0.0216
N3 Emotional	0.1270	0.0161
N3 Weighted	0.1403	0.0197

Table 4: Denis 2021 (TMR) SP Amplitude and Memory Pearson's r Correlation Table

	nREM2	nREM3
Neutral	-0.2098	-0.2458
Emotional	-0.1747	-0.2705
Weighted	-0.1984	-0.2802

Table 5: Denis 2021 (TMR) CP Strength and Memory Pearson's r Correlation Table

	nREM2	nREM3
Neutral	0.1797	0.1981
Emotional	0.1777	0.2963
Weighted	0.1901	0.2832

Table 6: Denis 2021 (TMR) CP Percentage and Memory Pearson's r Correlation Table

	nREM2	nREM3
Neutral	-0.0573	0.1915
Emotional	-0.3933	-0.0754
Weighted	-0.3074	0.0085

Hahn2020

Table 7: Hahn 2020 Child CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Frontal	0.3191	0.1018
Central	0.2569	0.0660
Parietal and Occipital	0.3059	0.0936

Table 8: Hahn 2020 Adolescent CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Frontal	0.4859	0.2361
Central	0.0971	0.0094
Parietal and Occipital	0.5138	0.2640

Table 9: Hahn 2020 SP Amplitude and Memory Pearson's r Correlation Table

	Child	Adolescent
Frontal	-0.1877	0.2143
Central	-0.2250	0.3446
Parietal and Occipital	-0.2796	0.2990

Table 10: Hahn 2020 CP Strength and Memory Pearson's r Correlation Table

	Child	Adolescent
Frontal	-0.0568	0.3792
Central	0.1827	-0.0797
Parietal and Occipital	-0.1048	-0.0129

Table 11: Hahn 2020 CP Percentage and Memory Pearson's r Correlation Table

	N2	N3
Child	0.0584	0.1432
Adolescent	-0.5107	-0.2487

Kurz2023

Table 12: Kurz 2023 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Slow Frontal	0.1322	0.0175
Slow Central	0.4461	0.1990
Slow Parietal	0.1708	0.0292
Fast Frontal	0.2731	0.0746
Fast Central	0.2777	0.0771
Fast Parietal	0.1865	0.0348

Table 13: Kurz 2023 SP Amplitude and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	0.4792	0.1308
Central	0.5582	0.1738
Parietal	0.5941	0.0830

Table 14: Kurz 2023 CP Strength and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	0.2768	-0.0574

	Fast.Spindle	Slow.Spindle
Central	0.3140	0.1543
Parietal	0.2721	0.1262

Donnelly2022

Table 15: Donnelly 2022 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Frontal	0.3509	0.1231
Central	0.3510	0.1232
Parietal and Occipital	0.6296	0.3964

Table 16: Donnelly 2022 SP Amplitude and Memory Pearson's r Correlation Table

	Frontal	Central	Parietal and Occipital
Correlation	0.5232	0.5343	0.3783

Table 17: Donnelly 2022 CP Strength and Memory Pearson's r Correlation Table

	Frontal	Central	Parietal and Occipital
Correlation	-0.2253	0.0043	0.0886

Denis2022

Table 18: Denis 2022 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Slow Frontal	0.4076	0.1661
Slow Central	0.3961	0.1569
Slow Parietal and Occipital	0.2586	0.0669
Fast Frontal	0.3818	0.1458
Fast Central	0.2439	0.0595
Fast Parietal and Occipital	0.1751	0.0307

Table 19: Denis 2022 SP Amplitude and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	-0.0145	-0.0222
Central	-0.0711	-0.0896
Parietal and Occipital	-0.1847	-0.2770

Table 20: Denis 2022 CP Strength and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	0.1690	-0.0882
Central	0.1577	-0.1101
Parietal and Occipital	0.1883	-0.0144

Table 21: Denis 2022 CP Percentage and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	-0.0619	0.0698
Central	0.0485	0.1087
Parietal and Occipital	0.0591	-0.1029

Mylonas2020

Table 22: Mylonas 2020 Coupling and Memory Correlation Table

Phase.Circlin.R	Phase.R.squared	Amplitude	Strength	SPcSO	SOcSP
0.3801	0.1445	-0.1982	0.0508	-0.0289	0.055

Hahn2022

Table 23: Hahn 2022 CP Phase and Memory Circular Linear Correlation Table

	Adolescent	Young.Adult
Frontal	0.4950	0.3067
Central	0.2770	0.2908
Parietal and Occipital	0.4205	0.3061

Table 24: Hahn 2022 SP Amplitude and Memory Circular Linear Correlation Table

	Adolescent	Young.Adult
Frontal	-0.2557	-0.2941
Central	-0.2067	-0.0872
Parietal and Occipital	-0.4873	-0.3348

Table 25: Hahn 2022 CP Strength and Memory Pearson's r Correlation Table

	Adolescent	Young.Adult
Frontal	0.0070	-0.0387
Central	0.5078	0.6233
Parietal and Occipital	-0.2873	0.3101

Mylonas2022

Table 26: Mylonas 2022 Coupling and Memory Correlation Table

Phase.Circlin.R	Phase.R.squared	Amplitude	Strength	SPcSO
0.3818	0.1458	0.3421	-0.0862	-0.1803

Solano2022

Table 27: Solano 2022 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Fast N2 Frontal	0.8022	0.6436
Fast N2 Central	0.4061	0.1649
Fast N2 Parietal	0.4912	0.2413
Fast N3 Frontal	0.6944	0.4822
Fast N3 Central	0.4623	0.2137
Fast N3 Parietal	0.1923	0.0370
Slow N2 Frontal	0.5664	0.3208
Slow N2 Central	0.2203	0.0485
Slow N2 Parietal	0.2638	0.0696
Slow N3 Frontal	0.1768	0.0313
Slow N3 Central	0.4515	0.2038

	Circlin.R	R.squared
Slow N3 Parietal	0.2310	0.0534

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Table 28: Solano 2022 CP Strength and Memory Pearson's r Correlation Table

	Fast.N2	Fast.N3	Slow.N2	Slow.N3
Frontal	-0.2056	0.0946	-0.3233	-0.3958
Central	-0.3257	-0.2465	0.2603	-0.3682
Parietal	-0.4661	-0.5492	0.4755	-0.3698

Table 29: Solano 2022 CP Percentage and Memory Pearson's r Correlation Table

	Fast.N2	Fast.N3	Slow.N2	Slow.N3
Frontal	0.4174	0.3955	0.0969	0.5478
Central	0.3409	0.4175	0.2301	0.2490
Parietal	-0.2357	0.1680	-0.3531	0.2353

Kurz2021

Table 30: Kurz 2021 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Slow Frontal	0.3790	0.1437
Slow Central	0.1285	0.0165
Slow Parietal	0.1639	0.0269
Fast Frontal	0.6272	0.3933
Fast Central	0.3861	0.1491
Fast Parietal	0.4001	0.1601

Table 31: Kurz 2021 SP Amplitude and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	0.2517	-0.1948
Central	0.3392	-0.1647
Parietal	0.1728	-0.2322

Table 32: Kurz 2021 CP Strength and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	0.1347	0.4738
Central	0.0261	0.3821
Parietal	-0.0229	0.3210

Table 33: Kurz 2021 CP Percentage and Memory Pearson's r Correlation Table

	Fast.Spindle	Slow.Spindle
Frontal	-0.1133	-0.0224
Central	0.0636	0.0598
Parietal	0.0388	0.0542

Cox2018

Table 34: Cox 2018 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
N2 Slow Frontal	0.2607	0.0679
N2 Fast Frontal	0.1643	0.0270
N2 Slow Central	0.2808	0.0789
N2 Fast Central	0.4249	0.1805
N2 Slow Parietal	0.3393	0.1152
N2 Fast Parietal	0.4315	0.1862
N3 Slow Frontal	0.4282	0.1834
N3 Fast Frontal	0.3498	0.1224
N3 Slow Central	0.0727	0.0053
N3 Fast Central	0.0178	0.0003
N3 Slow Parietal	0.2765	0.0764
N3 Fast Parietal	0.3282	0.1077

	Circlin.R	R.squared

Table 35: Cox 2018 CP Strength and Memory Pearson's r Correlation Table

	Fast.N2	Fast.N3	Slow.N2	Slow.N3
Frontal	-0.1661	-0.0588	-0.1703	-0.0342
Central	-0.1047	-0.2838	0.4167	-0.5230
Parietal	0.0921	0.1584	-0.1650	0.4173

Zhang2020

Table 36: Zhang 2020 CP Phase and Memory Circular Linear Correlation Table

	Circlin.R	R.squared
Frontal	0.2695	0.0726
Central	0.1816	0.0330
Parietal and Occipital	0.1679	0.0282

```
Zhang2020_avg_mi <- remove_outliers(Zhang2020_avg, scale_columns =  c("Favg_mi","Cavg_mi",
```

```
[1] "2 rows removed: 10, 28"
```

```
Zhang2020_avg_mvl <- remove_outliers(Zhang2020_avg, scale_columns =  c("Favg_mvl","Cavg_mv
```

```
[1] "0 rows removed: "
```

Table 37: Zhang 2020 (MI) CP Strength and Memory Pearson's r Correlation Table

	Correlation
Frontal	0.2379
Central	0.1240
Parietal and Occipital	0.1058

```
     min    Q1 median    Q3   max  mean   sd  n missing
-0.06532 10.11  13.09 31.78 81.72 22.89 23.3 26       0
```

```
    min    Q1 median    Q3   max  mean    sd  n missing
0.01529 6.572  15.17 44.54 171.6 34.22 41.17 26       0
```

```
    min   Q1 median    Q3   max  mean    sd  n missing
-0.1258 14.2  30.51 51.23 144.4 37.72 32.77 26       0
```

Table 38: Zhang 2020 (MVL) CP Strength and Memory Pearson's r Correlation Table

	Correlation
Frontal	0.0445
Central	-0.1356
Parietal and Occipital	-0.0154

```
Zhangpct_avg <- Zhangpct |>
  rowwise() |>
  mutate(
    Favg_pct = {
      ratios <- c(F3_sosp/F3_sp, Fz_sosp/Fz_sp, F4_sosp/F4_sp)
      ratios[is.infinite(ratios)] <- 10
      mean(ratios, na.rm = TRUE)
    },
    Cavg_pct = {
      ratios <- c(C3_sosp/C3_sp, Cz_sosp/Cz_sp, C4_sosp/C4_sp)
      ratios[is.infinite(ratios)] <- 10
      mean(ratios, na.rm = TRUE)
    },
    POavg_pct = {
      ratios <- c(P3_sosp/P3_sp, Pz_sosp/Pz_sp, P4_sosp/P4_sp, O1_sosp/O1_sp, O2_sosp/O2_s
      ratios[is.infinite(ratios)] <- 10
      mean(ratios, na.rm = TRUE)
    }
  )
#> view(Zhangpct_avg)
is_odd <- seq_len(nrow(Zhangpct_avg)) %% 2 == 1
is_even <- seq_len(nrow(Zhangpct_avg)) %% 2 == 0

zhangpct_avg_nrem2_raw <- Zhangpct_avg[is_odd, ]
zhangpct_avg_sws_raw <- Zhangpct_avg[is_even, ]
```

```
[1] "3 rows removed: 10, 22, 25"
```

```
[1] "3 rows removed: 16, 22, 23"
```

Table 39: Zhang 2020 CP Percentage and Memory Pearson's r Correlation Table

	nREM2	sws
Frontal	-0.0844	0.1661
Central	0.2402	0.1743
Parietal and Occipital	0.0506	0.1113

```
   min     Q1 median     Q3   max   mean     sd  n missing
0.1285 0.1957 0.2781 0.3522 3.264 0.4208 0.6079 25       0
```

```
    min     Q1 median     Q3   max  mean     sd  n missing
0.06849 0.1271 0.2026 0.2551 3.473 0.333 0.6629 25       0
```

```
    min      Q1  median     Q3   max   mean    sd  n missing
0.01376 0.04755 0.08191 0.1871 6.724 0.3899 1.324 25       0
```

```
   min     Q1 median     Q3   max   mean    sd  n missing
0.1092 0.2082 0.3832 0.8696 4.461 0.7819 1.065 25       0
```

```
   min     Q1 median    Q3   max mean     sd  n missing
0.2432 0.4638 0.6618 1.374 4.284 1.03 0.9001 25       0
```

```
  min     Q1 median     Q3   max  mean    sd  n missing
0.184 0.3294 0.4184 0.8562 24.03 1.876 4.858 25       0
```

Baena2023

Nicolas2022

```
Nicolas2022_sleep <- data.frame()

for (row in Nicolas2022_sleep_raw) {
  row_data <- str_split_fixed(row, ",", 12)
  Nicolas2022_sleep <- rbind(Nicolas2022_sleep, as.data.frame(row_data))
}
colnames <- c('Sub','Channel','Count','Density','Duration','Amplitude','RMS','AbsPower','R
```

```r
colnames(Nicolas2022_sleep) <- colnames

Nicolas2022_sleep <- Nicolas2022_sleep[-1, ]
#> view(Nicolas2022_sleep)

Nicolas2022_sleep_wide <- Nicolas2022_sleep |>
  pivot_wider(names_from = Channel,
              values_from = Amplitude,
              id_cols = Sub)
Nicolas2022_sleep_wide$C3 <- c(60.87314849, Nicolas2022_sleep_wide$C3[-1])
#> view(Nicolas2022_sleep_wide)
```

```r
Nicolas2022_mem <- data.frame()

for (row in Nicolas2022_mem_raw) {
  row_data <- str_split_fixed(row, ",", 5)
  Nicolas2022_mem <- rbind(Nicolas2022_mem, as.data.frame(row_data))
}
colnames <- c('Sub', 'Sequence', 'Condition', 'Time', 'Gain_RT')
colnames(Nicolas2022_mem) <- colnames

Nicolas2022_mem_wide <- Nicolas2022_mem |>
  pivot_wider(names_from = c("Condition", "Time"),
              values_from = Gain_RT,
              id_cols = Sub) |>
  rename(react_early = `react_early`,
         react_late = `react_late`,
         notreact_early = `notReact_early`,
         notreact_late = `notReact_late`)
#> view(Nicolas2022_mem_wide)

Nicolas2022_mem_wide$notreact_late <- as.numeric(Nicolas2022_mem_wide$notreact_late)
Nicolas2022_mem_wide$notreact_early <- as.numeric(Nicolas2022_mem_wide$notreact_early)
Nicolas2022_mem_wide <- Nicolas2022_mem_wide |>
  mutate(notreact_retention = (notreact_late - notreact_early))
```

```r
Nicolas2022_sleep_wide <- Nicolas2022_sleep_wide |>
  mutate_all(~ as.numeric(.))
```

```
Warning: There was 1 warning in `mutate()`.
i In argument: `Sub = (structure(function (..., .x = ..1, .y = ..2, . = ..1)
```

```
  ...`.
Caused by warning in `as.numeric()`:
! NAs introduced by coercion
```

```r
Nicolas2022_sleep_wide <- Nicolas2022_sleep_wide |>
  rowwise() |>
mutate(
 Favg = Fz,
 Cavg = mean(c(C3, C4, Cz), na.rm = TRUE),
 POavg = mean(c(Pz, Oz), na.rm = TRUE))

amp <- remove_outliers(Nicolas2022_sleep_wide, scale_columns = c("Favg", "Cavg", "POavg"),
```

```
[1] "0 rows removed: "
[1] "Corrisponding rows removed in the memory matrix."
```

```r
Nicolas2022_sleep_wide <- amp$sleepchar_rem
Nicolas2022_mem_wide <- amp$memory_rem
```

```r
# Calculate correlation coefficients between spindle amplitude and memory in each channel
cor <- c(
  "Frontal" = cor(Nicolas2022_sleep_wide$Favg ~ Nicolas2022_mem_wide$notreact_retention, u
  "Central" = cor(Nicolas2022_sleep_wide$Cavg ~ Nicolas2022_mem_wide$notreact_retention, u
  "Parietal and Occipital" = cor(Nicolas2022_sleep_wide$POavg ~ Nicolas2022_mem_wide$notre

# Create the table
cortable("Nicolas 2022", 2, flip = FALSE, "Correlation" = cor)
```

Table 40: Nicolas 2022 SP Amplitude and Memory Pearson's r Correlation Table

	Correlation
Frontal	0.0938
Central	-0.0532
Parietal and Occipital	-0.2523

IV. References

1. Mardia, K. V. (1976). Linear-Circular Correlation Coefficients and Rhythmometry. *Biometrika,* 63(2), 403–405. https://doi.org/10.2307/2335637

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3. R Core Team (2022). R: A language and environment for statistical computing. *R Foundation for Statistical Computing, Vienna, Austria.* https://www.R-project.org/.