Sensitivity analyses — HPT (Czech data)

Robustness checks for scoring, ideology operationalisation, exclusions, and random-slopes

HPT and Extremism project

2025-12-13

Contents

1 Purpose and scope

This file documents **exploratory robustness checks** of our main results. We vary how HPT is scored, how ideology is operationalised, which observations are included, and whether class-level **random slopes** are needed. The goal is to see if substantive conclusions survive reasonable perturbations—**not** to hunt for significance.

HPT scoring follows the Hartmann–Hasselhorn / Huijgen instrument logic; note earlier reports that ROA items can behave inconsistently across samples, motivating ROA-free alternatives here. We also leverage the FR-LF dimensions RD and NS for ideology variants. All results explicitly use **reversed POP items** so that higher scores mean **more contextualised/agent-aware** reasoning.

1.1 Setup

```r
# Core packages
library(tidyverse)
library(lme4)
library(lmerTest)
library(broom)
library(broom.mixed)
library(performance)
library(glue)
library(gt)

# Nice printing
theme_set(theme_bw())
```

1.2 Data

```r
# Load the dataset created in 00_data-preparation
load("normalised_responses.RData")
stopifnot(exists("normalised_responses"))
dat_raw <- normalised_responses

# Cluster identifiers
dat_raw <- dat_raw %>%
  mutate(
    school_id   = as.factor(school_id),
    class_label = as.factor(class_label),
    class_id    = interaction(school_id, class_label, drop = TRUE)
  )
```

```r
# Reverse POP (1-4) so higher = more contextualised
POP_rev_items <- paste0("POP", 1:3)
dat_raw <- dat_raw %>%
  mutate(across(all_of(POP_rev_items), ~ 5 - as.numeric(.), .names = "{.col}_rev")) %>%
  mutate(
    HPT_POP_rev = rowMeans(across(paste0(POP_rev_items, "_rev")), na.rm = TRUE),
    HPT_CONT    = rowMeans(across(CONT1:CONT3), na.rm = TRUE),
    HPT_ROA     = rowMeans(across(ROA1:ROA3),   na.rm = TRUE),
    # Canonical composites
    HPT_CTX6    = rowMeans(cbind(HPT_POP_rev, HPT_CONT), na.rm = TRUE),
    HPT_TOT9    = rowMeans(cbind(HPT_POP_rev, HPT_CONT, HPT_ROA), na.rm = TRUE)
  )
```

Variable dictionary. KN, POP/ROA/CONT, RD/NS, KSA facets, SDR as per codebook.

2 1. Scoring variants for HPT (with POP reversed)

```r
# IMPORTANT: use reversed POP columns in all totals

dat <- dat_raw %>%
  mutate(
    HPT_total_9 = rowMeans(across(c(paste0("POP",1:3, "_rev"), ROA1:ROA3, CONT1:CONT3)), na.rm = TRUE),
    HPT_total_8 = rowMeans(across(c(paste0("POP",1:3, "_rev"), ROA2:ROA3, CONT1:CONT3)), na.rm = TRUE), # drop ROA1
    HPT_total_6 = rowMeans(across(c(paste0("POP",1:3, "_rev"), CONT1:CONT3)), na.rm = TRUE)             # no ROA
  )

# Means & SDs so the reader sees scale location and spread
hpt_desc <- dat %>%
  summarise(
    `9-item (POP_rev + ROA + CONT)` := mean(HPT_total_9,  na.rm=TRUE),
    `8-item (drop ROA1)`            := mean(HPT_total_8,  na.rm=TRUE),
    `6-item (no ROA)`               := mean(HPT_total_6,  na.rm=TRUE),
    .groups = "drop"
  ) %>%
  pivot_longer(everything(), names_to = "Score", values_to = "Mean")

hpt_sd <- dat %>%
  summarise(
    `9-item (POP_rev + ROA + CONT)` := sd(HPT_total_9,  na.rm=TRUE),
```

HPT scoring variants (POP reversed): means and SDs

Score	Mean	SD
9-item (POP_rev + ROA + CONT)	2.84	0.49
8-item (drop ROA1)	2.84	0.50
6-item (no ROA)	2.86	0.57

```r
    `8-item (drop ROA1)`            := sd(HPT_total_8,   na.rm=TRUE),
    `6-item (no ROA)`               := sd(HPT_total_6,   na.rm=TRUE)
  ) %>%
  pivot_longer(everything(), names_to = "Score", values_to = "SD")

hpt_desc_tbl <- left_join(hpt_desc, hpt_sd, by = "Score")

hpt_desc_tbl %>%
  gt() %>%
  fmt_number(columns = c(Mean, SD), decimals = 2) %>%
  tab_header(title = "HPT scoring variants (POP reversed): means and SDs")
```

3 2. Ideology operationalisations

```r
dat <- dat %>%
  mutate(
    KN_total   = rowSums(across(KN1:KN6), na.rm = TRUE),
    SDR_total  = rowSums(across(starts_with("SDR")), na.rm = TRUE),
    NS_sum     = rowSums(across(NS1:NS3), na.rm = TRUE),
    RD_sum     = rowSums(across(RD1:RD3), na.rm = TRUE),
    FRLF_mini  = NS_sum + RD_sum,
    KSA_A      = rowSums(across(A1:A3), na.rm = TRUE),
    KSA_U      = rowSums(across(U1:U3), na.rm = TRUE),
    KSA_K      = rowSums(across(K1:K3), na.rm = TRUE),
    KSA_total  = KSA_A + KSA_U + KSA_K
  ) %>%
  mutate(across(c(NS_sum, RD_sum, FRLF_mini, KSA_total, KN_total, SDR_total), scale, .names = "{.col}_z"))

# Show quick reliables for predictors (descriptive only)
```

Predictor summaries (raw scale units)

KN_mean	KN_sd	SDR_mean	SDR_sd	NS_mean	NS_sd	RD_mean	RD_sd	KSA_mean	KSA_sd
3.153846	1.657939	14.61111	3.828743	7.136752	2.923652	7.34188	2.939044	25.13248	6.821102

```
ideo_desc <- dat %>% summarise(
  KN_mean = mean(KN_total, na.rm=TRUE), KN_sd = sd(KN_total, na.rm=TRUE),
  SDR_mean = mean(SDR_total, na.rm=TRUE), SDR_sd = sd(SDR_total, na.rm=TRUE),
  NS_mean = mean(NS_sum, na.rm=TRUE), NS_sd = sd(NS_sum, na.rm=TRUE),
  RD_mean = mean(RD_sum, na.rm=TRUE), RD_sd = sd(RD_sum, na.rm=TRUE),
  KSA_mean = mean(KSA_total, na.rm=TRUE), KSA_sd = sd(KSA_total, na.rm=TRUE)
)
ideo_desc %>% gt() %>% tab_header(title = "Predictor summaries (raw scale units)")
```

4 3. Exclusions: knowledge outliers & extreme SDR

```
# Tukey fence for KN; top 10% for SDR
kn_q <- quantile(dat$KN_total, probs = c(.25, .75), na.rm = TRUE)
kn_iqr <- kn_q[2]-kn_q[1]
kn_low <- kn_q[1] - 1.5*kn_iqr
kn_high<- kn_q[2] + 1.5*kn_iqr

sdr_p90 <- quantile(dat$SDR_total, probs = .90, na.rm = TRUE)

dat <- dat %>%
  mutate(
    excl_KN  = KN_total < kn_low | KN_total > kn_high,
    excl_SDR = SDR_total >= sdr_p90,
    keep_all = TRUE,
    keep_excl= !(excl_KN | excl_SDR)
  )

excl_tbl <- tibble(
  Criterion = c("Total N", "Drop KN outliers", "Drop top-10% SDR", "Kept (both rules)"),
  N = c(nrow(dat), sum(dat$excl_KN, na.rm=TRUE), sum(dat$excl_SDR, na.rm=TRUE), sum(dat$keep_excl, na.rm=TRUE))
) %>%
```

Exclusion counts and percentages

Criterion	N	Percent
Total N	234	100%
Drop KN outliers	0	0%
Drop top-10% SDR	25	11%
Kept (both rules)	209	89%

```r
  mutate(Percent = scales::percent(N / first(N)))

excl_tbl %>% gt() %>% tab_header(title = "Exclusion counts and percentages")
```

5 4. Mixed models with clustering & random slopes

```r
fit_models <- function(data, hpt_var, ideol_var){
  form0 <- as.formula(glue(
    "{hpt_var} ~ {ideol_var} + KN_total_z + SDR_total_z + (1 | school_id) + (1 | class_id)"
  ))
  form1 <- as.formula(glue(
    "{hpt_var} ~ {ideol_var} + KN_total_z + SDR_total_z + (1 | school_id) + (1 + {ideol_var} | class_id)"
  ))
  m0 <- lmer(form0, data = data)
  m1 <- try(lmer(form1, data = data), silent = TRUE)
  if (inherits(m1, "try-error") || isTRUE(isSingular(m1))) m1 <- NULL
  list(m0 = m0, m1 = m1)
}

summarise_model <- function(m){
  fx <- broom.mixed::tidy(m, effects = "fixed", conf.int = TRUE)
  r2 <- performance::r2_nakagawa(m)
  fx %>% mutate(R2_marg = r2$R2_marginal, R2_cond = r2$R2_conditional)
}
```

```r
hpt_vars   <- c("HPT_total_9","HPT_total_8","HPT_total_6")
ideol_vars <- c("NS_sum_z","FRLF_mini_z","KSA_total_z")
```

```r
# Full sample
full_grid <- tidyr::expand_grid(hpt = hpt_vars, ideol = ideol_vars) %>%
  mutate(fits = map2(hpt, ideol, ~fit_models(dat %>% filter(keep_all), .x, .y)),
         m0    = map(fits, "m0"),
         m1    = map(fits, "m1"))

# Exclusion sample
excl_grid <- tidyr::expand_grid(hpt = hpt_vars, ideol = ideol_vars) %>%
  mutate(fits = map2(hpt, ideol, ~fit_models(dat %>% filter(keep_excl), .x, .y)),
         m0    = map(fits, "m0"),
         m1    = map(fits, "m1"))
```

```r
collect_table <- function(grid, label){
  out0 <- grid %>% mutate(t0 = map(m0, summarise_model)) %>% unnest(t0) %>% mutate(model = "RI")
  out1 <- grid %>% filter(!map_lgl(m1, is.null)) %>% mutate(t1 = map(m1, summarise_model)) %>% unnest(t1) %>% mutate(model = "RS")
  bind_rows(out0, out1) %>% mutate(sample = label)
}

tab_full <- collect_table(full_grid, "Full")
```

```
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
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## Random effect variances not available. Returned R2 does not account for random effects.
```

```
## Warning: There were 9 warnings in `mutate()`.
## The first warning was:
## i In argument: `t0 = map(m0, summarise_model)`.
## Caused by warning:
## ! Can't compute random effect variances. Some variance components equal
##   zero. Your model may suffer from singularity (see `?lme4::isSingular`
##   and `?performance::check_singularity`).
##   Decrease the `tolerance` level to force the calculation of random effect
##   variances, or impose priors on your random effects parameters (using
##   packages like `brms` or `glmmTMB`).
## i Run `dplyr::last_dplyr_warnings()` to see the 8 remaining warnings.
## Random effect variances not available. Returned R2 does not account for random effects.
```

```
## Warning: There was 1 warning in `mutate()`.
## i In argument: `t1 = map(m1, summarise_model)`.
## Caused by warning:
## ! Can't compute random effect variances. Some variance components equal
##   zero. Your model may suffer from singularity (see `?lme4::isSingular`
##   and `?performance::check_singularity`).
##   Decrease the `tolerance` level to force the calculation of random effect
##   variances, or impose priors on your random effects parameters (using
##   packages like `brms` or `glmmTMB`).
```

```r
tab_excl <- collect_table(excl_grid, "Exclusions applied")
```

```
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
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## Random effect variances not available. Returned R2 does not account for random effects.
```

```
## Warning: There were 9 warnings in `mutate()`.
## The first warning was:
## i In argument: `t0 = map(m0, summarise_model)`.
## Caused by warning:
## ! Can't compute random effect variances. Some variance components equal
##   zero. Your model may suffer from singularity (see `?lme4::isSingular`
##   and `?performance::check_singularity`).
##   Decrease the `tolerance` level to force the calculation of random effect
##   variances, or impose priors on your random effects parameters (using
##   packages like `brms` or `glmmTMB`).
## i Run `dplyr::last_dplyr_warnings()` to see the 8 remaining warnings.
```

```
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
## Random effect variances not available. Returned R2 does not account for random effects.
```

```
## Warning: There were 3 warnings in `mutate()`.
## The first warning was:
## i In argument: `t1 = map(m1, summarise_model)`.
## Caused by warning:
## ! Can't compute random effect variances. Some variance components equal
##   zero. Your model may suffer from singularity (see `?lme4::isSingular`
##   and `?performance::check_singularity`).
##   Decrease the `tolerance` level to force the calculation of random effect
##   variances, or impose priors on your random effects parameters (using
##   packages like `brms` or `glmmTMB`).
## i Run `dplyr::last_dplyr_warnings()` to see the 2 remaining warnings.
```

```r
# Keep only ideology terms + intercept
tab_models <- bind_rows(tab_full, tab_excl) %>%
  filter(term %in% c("(Intercept)", "NS_sum_z", "FRLF_mini_z", "KSA_total_z")) %>%
  mutate(
    ideol = recode(term, NS_sum_z = "NS (z)", FRLF_mini_z = "FR-LF: RD+NS (z)", KSA_total_z = "KSA-3 total (z)", `(Intercept)` = "(Intercept)"
    hpt = recode(hpt,
      HPT_total_9 = "HPT 9-item (POP_rev + ROA + CONT)",
      HPT_total_8 = "HPT 8-item (drop ROA1)",
      HPT_total_6 = "HPT 6-item (no ROA)"
    )
  ) %>%
  select(sample, hpt, model, ideol, estimate, conf.low, conf.high, p.value, R2_marg, R2_cond) %>%
  arrange(sample, hpt, ideol, model)

# Display as a compact table
(tab_models %>%
  mutate(across(c(estimate, conf.low, conf.high, R2_marg, R2_cond), ~round(., 3)),
         p.value = signif(p.value, 3)) %>%
  gt() %>%
  tab_header(title = "Multilevel models: ideology → HPT (POP reversed; controls: KN, SDR; school + class clustering)") %>%
  tab_spanner(label = "Effect (  and 95% CI)", columns = c(estimate, conf.low, conf.high)) %>%
  cols_label(sample="Sample", hpt="HPT score", model="Model", ideol="Predictor",
             estimate=" ", conf.low="CI low", conf.high="CI high", p.value="p",
             R2_marg="R² (marg.)", R2_cond="R² (cond.)"))
```

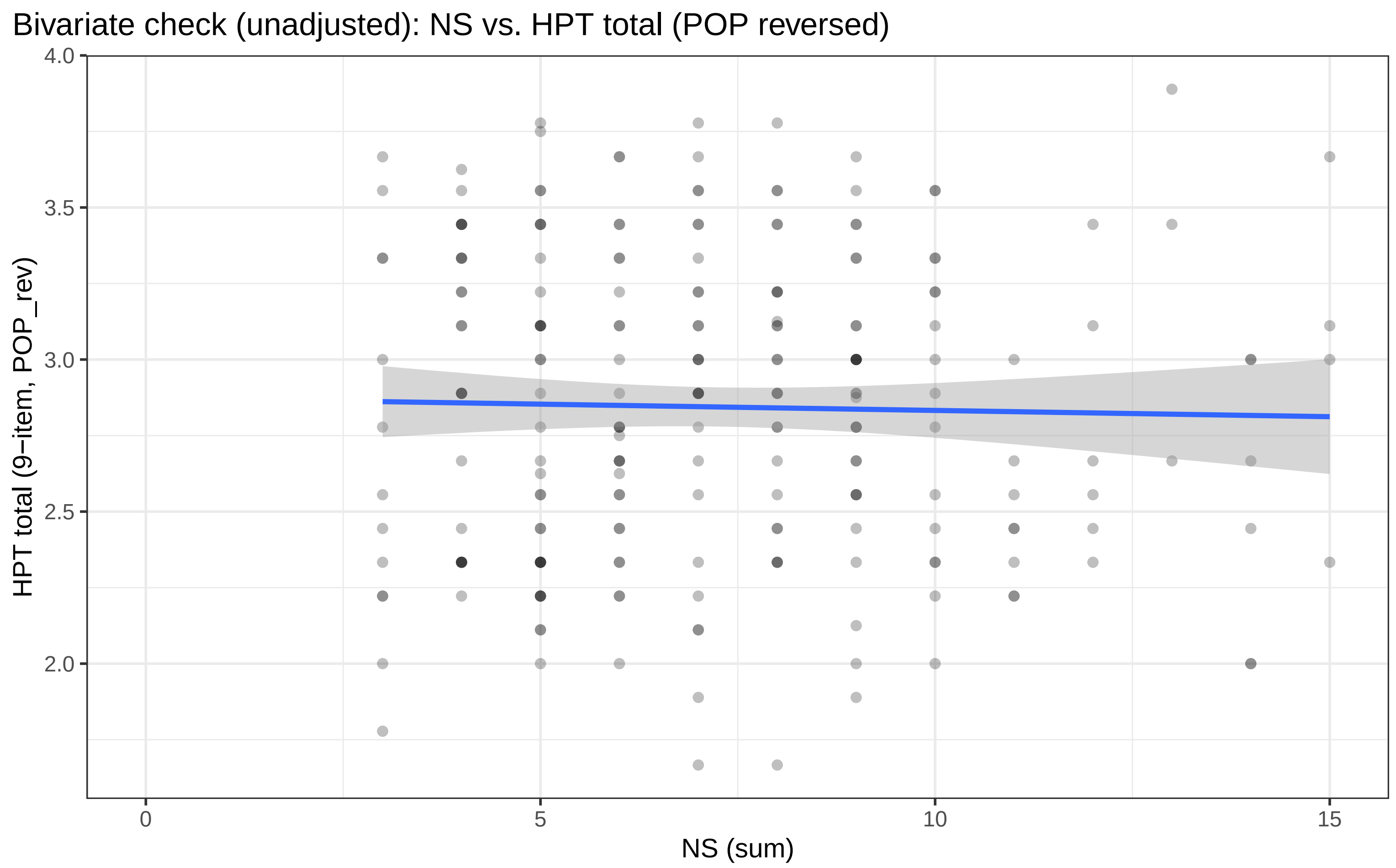
6 5. Sanity plots

```
dat %>%
  ggplot(aes(NS_sum, HPT_total_9)) +
  geom_point(alpha=.25) + geom_smooth(method="lm", se=TRUE) +
  labs(x="NS (sum)", y="HPT total (9-item, POP_rev)",
       title="Bivariate check (unadjusted): NS vs. HPT total (POP reversed)") +
  theme(plot.title.position="plot")
```

```
## `geom_smooth()` using formula = 'y ~ x'
```

```
## Warning: Removed 5 rows containing non-finite outside the scale range
## (`stat_smooth()`).
```

```
## Warning: Removed 5 rows containing missing values or values outside the scale
## range (`geom_point()`).
```


Bivariate check (unadjusted): NS vs. HPT total (POP reversed)

7 6. Read-outs for prose

- **Stable conclusions** across HPT **9/8/6** scoring → results **do not depend** on ROA items.
- **NS-only** **KSA-3** → supports the **ideological contamination** concern.
- Survives **knowledge/SDR exclusions** → less likely driven by misunderstanding or impression management.
- **Random slopes needed** → ideology effects differ **by class** (pedagogical moderation hypothesis).

8 Reproducibility appendix

```
sessionInfo()
```

```
## R version 4.4.2 (2024-10-31)
## Platform: x86_64-pc-linux-gnu
## Running under: Ubuntu 24.04.3 LTS
## 
## Matrix products: default
## BLAS:   /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.12.0 
## LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.12.0
## 
## locale:
##  [1] LC_CTYPE=en_US.UTF-8       LC_NUMERIC=C              
##  [3] LC_TIME=cs_CZ.UTF-8        LC_COLLATE=en_US.UTF-8    
##  [5] LC_MONETARY=cs_CZ.UTF-8    LC_MESSAGES=en_US.UTF-8   
##  [7] LC_PAPER=cs_CZ.UTF-8       LC_NAME=C                 
##  [9] LC_ADDRESS=C               LC_TELEPHONE=C            
## [11] LC_MEASUREMENT=cs_CZ.UTF-8 LC_IDENTIFICATION=C       
## 
## time zone: Europe/Prague
## tzcode source: system (glibc)
## 
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base     
## 
## other attached packages:
##  [1] gt_1.1.0            glue_1.8.0          performance_0.15.1 
##  [4] broom.mixed_0.2.9.6 broom_1.0.7         lmerTest_3.1-3     
##  [7] lme4_1.1-38         Matrix_1.7-1        lubridate_1.9.4    
## [10] forcats_1.0.0       stringr_1.5.1       dplyr_1.1.4        
## [13] purrr_1.1.0         readr_2.1.5         tidyr_1.3.1        
## [16] tibble_3.2.1        ggplot2_4.0.1       tidyverse_2.0.0    
## 
## loaded via a namespace (and not attached):
##  [1] gtable_0.3.6        xfun_0.54           insight_1.4.2      
##  [4] lattice_0.22-5      tzdb_0.5.0          numDeriv_2016.8-1.1
##  [7] vctrs_0.6.5         tools_4.4.2         Rdpack_2.6.4       
## [10] generics_0.1.3      parallel_4.4.2      pkgconfig_2.0.3    
## [13] RColorBrewer_1.1-3  S7_0.2.1            lifecycle_1.0.4    
## [16] compiler_4.4.2      farver_2.1.2        codetools_0.2-20   
## [19] htmltools_0.5.8.1   yaml_2.3.10         pillar_1.10.0
## [22] furrr_0.3.1         nloptr_2.2.1        MASS_7.3-61
## [25] reformulas_0.4.1    boot_1.3-31         nlme_3.1-166
## [28] parallelly_1.45.1   tidyselect_1.2.1    digest_0.6.37
## [31] stringi_1.8.4       future_1.68.0       listenv_0.10.0
## [34] labeling_0.4.3      splines_4.4.2       fastmap_1.2.0
## [37] grid_4.4.2          cli_3.6.5           magrittr_2.0.3
## [40] withr_3.0.2         scales_1.4.0        backports_1.5.0
## [43] timechange_0.3.0    rmarkdown_2.29      globals_0.18.0
## [46] hms_1.1.3           evaluate_1.0.5      knitr_1.50
## [49] rbibutils_2.3       mgcv_1.9-1          rlang_1.1.6
## [52] Rcpp_1.0.13-1       xml2_1.3.6          minqa_1.2.8
## [55] R6_2.6.1            fs_1.6.5
```

Multilevel models: ideology →HPT (POP reversed; controls: KN, SDR; school + class clustering)

				Effect (β and 95% CI)				
Sample	HPT score	Model	Predictor	β	CI low	CI high	p	R^2(marg.)
Exclusions applied	HPT 6-item (no ROA)	RI	(Intercept)	2.840	2.688	2.991	1.47e-07	0.106
Exclusions applied	HPT 6-item (no ROA)	RI	(Intercept)	2.840	2.691	2.990	1.69e-07	0.105
Exclusions applied	HPT 6-item (no ROA)	RI	(Intercept)	2.842	2.694	2.989	1.18e-07	0.108
Exclusions applied	HPT 6-item (no ROA)	RS	(Intercept)	2.835	2.682	2.989	9.91e-08	0.108
Exclusions applied	HPT 6-item (no ROA)	RS	(Intercept)	2.824	2.666	2.982	9.66e-08	0.105
Exclusions applied	HPT 6-item (no ROA)	RI	FR-LF: RD+NS (z)	-0.002	-0.083	0.079	9.60e-01	0.105
Exclusions applied	HPT 6-item (no ROA)	RS	FR-LF: RD+NS (z)	-0.002	-0.129	0.125	9.76e-01	0.105
Exclusions applied	HPT 6-item (no ROA)	RI	KSA-3 total (z)	-0.033	-0.118	0.052	4.44e-01	0.108
Exclusions applied	HPT 6-item (no ROA)	RI	NS (z)	0.027	-0.054	0.107	5.16e-01	0.106
Exclusions applied	HPT 6-item (no ROA)	RS	NS (z)	0.036	-0.094	0.165	5.45e-01	0.108
Exclusions applied	HPT 8-item (drop ROA1)	RI	(Intercept)	2.826	2.686	2.967	1.40e-07	0.125
Exclusions applied	HPT 8-item (drop ROA1)	RI	(Intercept)	2.827	2.688	2.966	1.39e-07	0.126
Exclusions applied	HPT 8-item (drop ROA1)	RI	(Intercept)	2.828	2.690	2.966	9.32e-08	0.129
Exclusions applied	HPT 8-item (drop ROA1)	RI	FR-LF: RD+NS (z)	-0.013	-0.083	0.058	7.25e-01	0.126
Exclusions applied	HPT 8-item (drop ROA1)	RI	KSA-3 total (z)	-0.032	-0.105	0.042	3.93e-01	0.129
Exclusions applied	HPT 8-item (drop ROA1)	RI	NS (z)	0.007	-0.063	0.077	8.47e-01	0.125
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	(Intercept)	2.819	2.668	2.970	7.81e-08	0.131
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	(Intercept)	2.820	2.671	2.968	8.91e-08	0.132
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	(Intercept)	2.820	2.672	2.968	7.27e-08	0.133
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RS	(Intercept)	2.820	2.660	2.979	1.67e-07	0.131
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	FR-LF: RD+NS (z)	-0.007	-0.076	0.062	8.47e-01	0.132
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	KSA-3 total (z)	-0.018	-0.090	0.054	6.24e-01	0.133
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RI	NS (z)	0.016	-0.052	0.085	6.42e-01	0.131
Exclusions applied	HPT 9-item (POP_rev + ROA + CONT)	RS	NS (z)	0.032	-0.081	0.144	5.41e-01	0.131
Full	HPT 6-item (no ROA)	RI	(Intercept)	2.842	2.703	2.981	1.04e-07	0.096
Full	HPT 6-item (no ROA)	RI	(Intercept)	2.843	2.706	2.981	1.33e-07	0.095
Full	HPT 6-item (no ROA)	RI	(Intercept)	2.846	2.712	2.980	1.67e-07	0.097
Full	HPT 6-item (no ROA)	RI	FR-LF: RD+NS (z)	0.017	-0.060	0.094	6.71e-01	0.095
Full	HPT 6-item (no ROA)	RI	KSA-3 total (z)	-0.026	-0.107	0.054	5.22e-01	0.097
Full	HPT 6-item (no ROA)	RI	NS (z)	0.032	-0.044	0.107	4.12e-01	0.096
Full	HPT 8-item (drop ROA1)	RI	(Intercept)	2.826	2.698	2.954	9.96e-08	0.123
Full	HPT 8-item (drop ROA1)	RI	(Intercept)	2.826	2.700	2.953	1.09e-07	0.123
Full	HPT 8-item (drop ROA1)	RI	(Intercept)	2.829	2.705	2.952	9.66e-08	0.126
Full	HPT 8-item (drop ROA1)	RS	(Intercept)	2.822	2.687	2.958	1.66e-07	0.126