clsa élcv
Canadian Longitudinal Study on Aging
Étude longitudinale canadienne sur le vieillissement

Derived Variables – Reliable Change Scores (Baseline to First Follow-up) for Cognitive Scores (COG) Normed for Age, Sex, Education Level, and Language (Comprehensive Assessment)

Reliable change scores are essentially normed change scores – what change is expected in cognitively healthy people and did the participant change more than would be expected?

Measuring change in cognition is a critical component of longitudinal aging studies, but there has been a gap between longitudinal aging studies and clinical practice because many methods measure change at the group level. To be clinically useful, longitudinal methods need to measure change at the level of the individual patient. Accounting for error in measurement is a critical component of clinical utility. Reliable change methods create comparison standards for cognitive change, which translate longitudinal data into clinically useful data that can be applied to individual patients. Reliable change methods can create comparison standards that can be used by clinicians and can be a platform for research on cognition within the CLSA. Creation of reliable change methods for the baseline and first follow up of the CLSA are critical in the determination of trajectories of cognitive impairment, such as cognitive decline due to dementia. Here we describe the derived reliable change indices (RCIs) for the cognition tests in the CLSA using methods that account for error in measurement and expected practice effects (O'Connell et al., submitted).

Six cognitive tests, producing seven scores, are in the neuropsychological battery used with the Comprehensive cohort: Immediate recall (REY I), delayed recall (REY II), animal naming task (AFT, with two scores based on strict scoring AF1 or lenient scoring AF2), mental alteration test (MAT), Stroop task performance summarized as the ratio of the time it took to complete the colour task divided by the time it took to complete the dot task (STP_INTFR_RATIO), and the COWAT task (using the summarized score FAS_TOTAL = FAS_F + FAS_A + FAS_S).
(Note: the normative comparison standards applied are the baseline norms, and practice effects are accounted for in the reliable change formulae. These were developed in a development sample (random sample of half the robustly healthy normative sample and cross validated on the other half – with excellent fit. Finally, we performed these separately for English- and French-speaking participants because of the difference in precision (i.e., O'Connell et al., 2021) for these samples, but the normed scores are invariant to language of administration. See O'Connell et al., 2022.

Scores for the prospective memory tests are not normed due to high degree of skewness in these tests due to a ceiling effect.

Twenty-five derived variables are created, indicating change in participant's change in performance, from baseline to first follow-up on the cognitive tests in the Comprehensive battery.

The time-interval between baseline (BL) and first follow-up (FU1) dates of testing in months. **For each cognitive test score, two variables are created**, relative to the norming sample (i.e., those who were neurologically healthy at both baseline and first follow-up):

- the person's reliable change index Z-score (referred to as 'change Zscore') that indicates the standardized and normed change in performance from baseline to first follow-up; and
- the person's reliable change index indicator (referred to as 'RCI') which is a classification of his/her performance into one of three categories: performance declined (-1), remained stable (0), or improved (+1) over time.

In addition, the same two derived variables are computed for changes in five composite scores constructed from the cognitive tests

- memory (MEM, construct based on REY I and REY II),
- executive function based on tests in common with the Tracking cohort (EF2, construct based on AF2 and MAT),
- executive function based on tests in the Comprehensive battery (EF4, construct based on AF2, MAT, STP and FAS),
- overall cognition based on tests in common with the Tracking cohort (REY I, REY II, AF2, and MAT), and
- overall cognition based on tests in the Comprehensive battery (REY I, REY II, AF2, MAT, STP and FAS).

Throughout this document, "neuro-healthy norming sample" refers to CLSA participants who were neuro-healthy at baseline and at follow-up testing. Separate norming samples were selected for consistent English and French language use on all tests.

The derivation of the change and RCI variables require normed test scores, which are described in the Cognition (COG) Normative Data (Comprehensive Assessment) documentation CLSA document: Norming COG COM (clsa-elcv.ca). Here we assume that the normed variables have all been created and exist in the dataset.

1. Time Interval between baseline and follow-up testing

Derived Variable Name: delta_T_months

Description: Used for computing the person's predicted score on a cognitive test. The interval is the difference in month from baseline to follow-up.

Based on: startdate_COM, startdate_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
Startdate_COF1 – startdate_COM	Both dates not missing	Number of months elapsed from baseline test date to follow-up test date.

2. REY I Reliable Change Z-score

Derived Variable Name: COG_REYI_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the REY I (immediate recall) test between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming

CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

COG_REYI_STARTLANG_COM,
COG_REYI_STARTLANG_COF1,
COG_REYI_NORMED_ZSCORE_COM,
delta_T_months

COG_REYI_LANG_COM,
COG_REYI_LANG_COF1,
COG_REYI_NORMED_ZSCORE_COF1,

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (REYI_LANG_COM), at follow-up (REYI_LANG_COF1) and at both times (REYI_LANG). The variable REYI_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
REYI_LANG_COM (or COF1) = 1	COG_REYI_STARTLANG_COM (or COF1) = 'en' and COG_REYI_LANGUAGE_COM (or COF1) = 'en'	REY I language of administration is English
REYI_LANG_COM (or COF1) = 2	COG_REYI_STARTLANG_COM (or COF1) = 'fr' and COG_REYI_LANGUAGE_COM (or COF1) = 'fr'	REY I language of administration is French
REYI_LANG = 1	IF REYI_LANG_COM = 1 and REYI_LANG_COF1 = 1	REY I was conducted in English at both baseline and at follow-up
REYI_LANG = 2	IF REYI_LANG_COM = 2 and REYI_LANG_COF1 = 2	REY I was conducted in French at both baseline and at follow-up
	The conditions above were not met.	REY I language variables are missing or inconsistent
REYI_FU1_pred = CONSTANT + COEFF1 * COG_REYI_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(REYI_LANG = 1 or 2)	Regression-based predicted REY I score (using participant's normed REY I Z-score at baseline and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_REYI_NORMED_ZSCORE_COF1 - REYI_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	(REYI_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

3. REY I Reliable Change Indicator (RCI)

Derived Variable Name: COG_REYI_RCI_COF1

Description: This variable is a recoding of COG_REYI_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_REYI_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_REYI_CHNG_ZSCORE_COF1 < -1.645	On REY I, participant's performance at follow-up declined since baseline.
0	COG_REYI_CHNG_ZSCORE_COF1 ≥ -1.645 and COG_REYI_CHNG_ZSCORE_COF1 < +1.645	On REY I, participant's performance at follow-remained stable compared with baseline.
+1	COG_REYI_CHNG_ZSCORE_COF1 > +1.645	On REY I, participant's performance at follow-up improved since baseline.

4. REY II Reliable Change Z-score

Derived Variable Name: COG_REYII_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the REY II (delayed recall) test between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

COG_REYII_STARTLANG_COM,
COG_REYII_STARTLANG_COF1,
COG_REYII_NORMED_ZSCORE_COM,
delta_T_months

COG_REYII_LANG_COM,
COG_REYII_LANG_COF1,
COG_REYII_NORMED_ZSCORE_COF1,

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (REYII_LANG_COM), at follow-up (REYII_LANG_COF1) and at both times (REYII_LANG). The variable REYII_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
REYII_LANG_COM (or COF1) = 1	COG_REYII_STARTLANG_COM (or COF1) = 'en' and COG_REYII_LANGUAGE_COM (or COF1) = 'en'	REY II language of administration is English
REYII_LANG_COM (or COF1) = 2	COG_REYII_STARTLANG_COM (or COF1) = 'fr' and COG_REYII_LANGUAGE_COM (or COF1) = 'fr'	REY II language of administration is French
REYII_LANG = 1	IF REYII_LANG_COM = 1 and REYII_LANG_COF1 = 1	REY II was conducted in English at both baseline and at follow-up
REYII_LANG = 2	IF REYII_LANG_COM = 2 and REYII_LANG_COF1 = 2	REY II was conducted in French at both baseline and at follow-up
	The conditions above were not met.	REY II language variables are missing or inconsistent
REYII_FU1_pred = CONSTANT + COEFF1 * COG_REYI_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(REYII_LANG = 1 or 2)	Regression-based predicted REY II score (using participant's normed REY II Z-score at baseline and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_REYII_NORMED_ZSCORE_COF1 - REYII_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	(REYII_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

5. REY II Reliable Change Indicator (RCI)

Derived Variable Name: COG_REYII_RCI_COF1

Description: This variable is a recoding of COG_REYII_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_REYII_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_REYII_CHNG_ZSCORE_COF1 < -1.645	On REY II, participant's performance at follow-up declined since baseline.
0	COG_REYII_CHNG_ZSCORE_COF1 ≥ -1.645 and COG_REYII_CHNG_ZSCORE_COF1 < +1.645	On REY II, participant's performance at follow-remained stable compared with baseline.
+1	COG_REYII_CHNG_ZSCORE_COF1 > +1.645	On REY II, participant's performance at follow-up improved since baseline.

6. AF1 Reliable Change Z-score

Derived Variable Name: COG_AF1_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the AFT – strict scoring (AF1) test between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

COG_AFT_STARTLANG_COM,
COG_AFT_STARTLANG_COF1,
COG_AF1_NORMED_ZSCORE_COM,
delta_T_months

COG_AFT_LANG_COM,
COG_AFT_LANG_COF1,
COG_AF1_NORMED_ZSCORE_COF1,

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (AFT_LANG_COM), at follow-up (AFT_LANG_COF1) and at both times (AFT_LANG). The variable AF1_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation

Value	Condition(s)	Description
AFT_LANG_COM (or COF1) = 1	COG_AFT_STARTLANG_COM (or COF1) = 'en' and COG_AFT_LANGUAGE_COM (or COF1) = 'en'	AFT language of administration is English
AFT_LANG_COM (or COF1) = 2	COG_AFT_STARTLANG_COM (or COF1) = 'fr' and COG_AFT_LANGUAGE_COM (or COF1) = 'fr'	AFT language of administration is French
AFT_LANG = 1	IF AFT_LANG_COM = 1 and AFT_LANG_COF1 = 1	AFT was conducted in English at both baseline and at follow-up
AFT_LANG = 2	IF AFT_LANG_COM = 2 and AFT_LANG_COF1 = 2	AFT was conducted in French at both baseline and at follow-up
.	The conditions above were not met.	AFT language variables are missing or inconsistent
AF1_FU1_pred = CONSTANT + COEFF1 * COG_AF1_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(AFT_LANG = 1 or 2)	Regression-based predicted AF1 score (using participant's normed AF1 Z-score at baseline and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_AF1_NORMED_ZSCORE_COF1 – AF1_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	(AFT_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

7. AF1 Reliable Change Indicator (RCI)

Derived Variable Name: COG_AF1_RCI_COF1

Description: This variable is a recoding of COG_AF1_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score.)

Based on: COG_AF1_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_AF1_CHNG_ZSCORE_COF1 < -1.645	On AF1, participant's performance at follow-up declined since baseline.
0	COG_AF1_CHNG_ZSCORE_COF1 ≥ -1.645 and COG_AF1_CHNG_ZSCORE_COF1 < +1.645	On AF1, participant's performance at follow-remained stable compared with baseline.
+1	COG_AF1_CHNG_ZSCORE_COF1 > +1.645	On AF1, participant's performance at follow-up improved since baseline.

8. AF2 Reliable Change Z-score

Derived Variable Name: COG_AF2_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the AFT – lenient scoring (AF2) test between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants

Based on:

COG_AFT_STARTLANG_COM,
COG_AFT_STARTLANG_COF1,
COG_AF2_NORMED_ZSCORE_COM,
delta_T_months

COG_AFT_LANG_COM,
COG_AFT_LANG_COF1,
COG_AF2_NORMED_ZSCORE_COF1,

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (AFT_LANG_COM), at follow-up (AFT_LANG_COF1) and at both times (AFT_LANG). The variable AF2_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
AFT_LANG_COM (or COF1) = 1	COG_AFT_STARTLANG_COM (or COF1) = 'en' and COG_AFT_LANGUAGE_COM (or COF1) = 'en'	AFT language of administration is English
AFT_LANG_COM (or COF1) = 2	COG_AFT_STARTLANG_COM (or COF1) = 'fr' and COG_AFT_LANGUAGE_COM (or COF1) = 'fr'	AFT language of administration is French
AFT_LANG = 1	IF AFT_LANG_COM = 1 and AFT_LANG_COF1 = 1	AFT was conducted in English at both baseline and at follow-up
AFT_LANG = 2	IF AFT_LANG_COM = 2 and AFT_LANG_COF1 = 2	AFT was conducted in French at both baseline and at follow-up
.	The conditions above were not met.	AFT language variables are missing or inconsistent
AF2_FU1_pred = CONSTANT + COEFF1 * COG_AF2_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	AFT_LANG = 1 or 2	Regression-based predicted AF2 score (using participant's normed AF2 Z-score at baseline and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_AF2_NORMED_ZSCORE_COF1 – AF2_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	(AFT_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

9. AF2 Reliable Change Indicator (RCI)

Derived Variable Name: COG_AF2_RCI_COF1

Description: This variable is a recoding of COG_AF2_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_AF2_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_AF2_CHNG_ZSCORE_COF1 < -1.645	On AF1, participant's performance at follow-up declined since baseline.
0	COG_AF2_CHNG_ZSCORE_COF1 ≥ -1.645 and COG_AF2_CHNG_ZSCORE_COF1 < +1.645	On AF1, participant's performance at follow-remained stable compared with baseline.
+1	COG_AF2_CHNG_ZSCORE_COF1 > +1.645	On AF1, participant's performance at follow-up improved since baseline.

10. MAT Reliable Change Z-score

Derived Variable Name: COG_MAT_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the MAT test between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

COG_MAT_STARTLANG_COM,
COG_MAT_STARTLANG_COF1,
COG_MAT_NORMED_ZSCORE_COM,
delta_T_months

COG_MAT_LANG_COM,
COG_MAT_LANG_COF1,
COG_MAT_NORMED_ZSCORE_COF1,

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (MAT_LANG_COM), at follow-up (MAT_LANG_COF1) and at both times (MAT_LANG). The variable MAT_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
MAT_LANG_COM (or COF1) = 1	COG_MAT_STARTLANG_COM (or COF1) = 'en' and COG_MAT_LANGUAGE_COM (or COF1) = 'en'	MAT language of administration is English
MAT_LANG_COM (or COF1) = 2	COG_MAT_STARTLANG_COM (or COF1) = 'fr' and COG_MAT_LANGUAGE_COM (or COF1) = 'fr'	MAT language of administration is French
MAT_LANG = 1	IF MAT_LANG_COM = 1 and MAT_LANG_COF1 = 1	MAT was conducted in English at both baseline and at follow-up
MAT_LANG = 2	IF MAT_LANG_COM = 2 and MAT_LANG_COF1 = 2	MAT was conducted in French at both baseline and at follow-up
.	The conditions above were not met.	MAT language variables are missing or inconsistent
MAT_FU1_pred = CONSTANT + COEFF1 * COG_MAT_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(MAT_LANG = 1 or 2)	Regression-based predicted MAT score (using participant's normed MAT Z-score at baseline and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_MAT_NORMED_ZSCORE_COF1 – MAT_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	MAT_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

11. MAT Reliable Change Indicator (RCI)

Derived Variable Name: COG_MAT_RCI_COF1

Description: This variable is a recoding of COG_MAT_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_MAT_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_MAT_CHNG_ZSCORE_COF1 < -1.645	On MAT, participant's performance at follow-up declined since baseline.
0	COG_MAT_CHNG_ZSCORE_COF1 ≥ -1.645 and COG_MAT_CHNG_ZSCORE_COF1 < +1.645	On MAT, participant's performance at follow-remained stable compared with baseline.
+1	COG_MAT_CHNG_ZSCORE_COF1 > +1.645	On MAT, participant's performance at follow-up improved since baseline.

12. STP Interference Ratio Reliable Change Z-score

Derived Variable Name: STP_RATIO_2_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the Stroop task between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

STP_STARTLANG_COM,
STP_RATIO_NORMED_ZSCORE_COM,
delta_T_months
STP_LANG_COF1,
STP_RATIO_NORMED_ZSCORE_COF1,

Temporary Variables: Two temporary variables are created. One language variable (STP_LANG) is created for coding English or French test administration at both baseline (STP_STARTLANG_COM) and follow-up (STP_LANG_COF1). The variable STP_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
STP_LANG = 1	IF STP_STARTLANG_COM = 'en' and STP_LANG_COF1 = 'en'	STP task was conducted in English at both baseline and at follow-up
STP_LANG = 2	IF STP_STARTLANG_COM = 'fr' and STP_LANG_COF1 = 'fr'	STP task was conducted in French at both baseline and at follow-up
.	The conditions above were not met.	STP language variables are missing or inconsistent
STP_FU1_pred = CONSTANT + COEFF1 * STP_RATIO_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(STP_LANG = 1 or 2)	Regression-based predicted STP ratio score (using participant's normed Z-scores and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(STP_RATIO_NORMED_ZSCORE_COF1 – STP_FU1_pred) / SD_residual where *SD*_RESID is the standard deviation of the residuals (observed - predicted) obtained from the neuro-healthy norming sample	(STP_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

13. STP Interference Ratio Reliable Change Indicator (RCI)

Derived Variable Name: STP_RATIO_RCI_COF1

Description: This variable is a recoding of STP_RATIO_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: STP_RATIO_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	STP_RATIO_CHNG_ZSCORE_COF1 < -1.645	On STP, participant's performance at follow-up declined since baseline.
0	STP_RATIO_CHNG_ZSCORE_COF1 ≥ -1.645 and STP_RATIO_CHNG_ZSCORE_COF1 < +1.645	On STP, participant's performance at follow-remained stable compared with baseline.
+1	STP_RATIO_CHNG_ZSCORE_COF1 > +1.645	On STP, participant's performance at follow-up improved since baseline.

14. FAS TOTAL Reliable Change Z-score

Derived Variable Name: FAS_TOTAL_CHNG_ZSCORE_COF1

Description: This variable indicates the participant's change in performance on the COWAT test (summed F, A, and S scores) between baseline testing and follow-up. It is normed for age, sex and education level and standardized (M=0, SD=1), relative to the neurologically healthy norming CLSA subsample. Norming and standardizing is done separately for English- and French-speaking participants.

Based on:

FAS_STARTLANG_COM, FAS_F_LANG_COM, FAS_A_LANG_COM, FAS_S_LANG_COM,
FAS_STARTLANG_COF1, FAS_F_LANG_COF1, FAS_A_LANG_COF1, FAS_S_LANG_COF1,
FAS_TOTAL_NORMED_ZSCORE_COM, FAS_TOTAL_NORMED_ZSCORE_COF1,
delta_T_months

Temporary Variables: Four temporary variables are created. Three language variables are created for coding English or French test administration at baseline (FAS_LANG_COM), at follow-up (FAS_LANG_COF1) and at both times (FAS_LANG_BLandFU1). The variable FAS_FU1_pred is the participant's predicted test score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

Value	Condition(s)	Description
FAS_LANG_COM (or COF1) = 1	FAS_STARTLANG_COM (or COF1) = 'en' and FAS_F_LANG_COM (or COF1) = 'en' and FAS_A_LANG_COM (or COF1) = 'en' and FAS_S_LANG_COM (or COF1) = 'en'	COWAT / FAS language of administration is English
FAS_LANG_COM (or COF1) = 2	FAS_STARTLANG_COM (or COF1) = 'fr' and FAS_F_LANG_COM (or COF1) = 'fr' and FAS_A_LANG_COM (or COF1) = 'fr' and FAS_S_LANG_COM (or COF1) = 'fr'	COWAT / FAS language of administration is French
FAS_LANG = 1	IF FAS_LANG_COM = 1 and FAS_LANG_COF1 = 1	FAS was conducted in English at both baseline and at follow-up
FAS_LANG = 2	IF FAS_LANG_COM = 2 and FAS_LANG_COF1 = 2	FAS was conducted in French at both baseline and at follow-up
.	The conditions above were not met.	FAS language variables are missing or inconsistent
FAS_FU1_pred = CONSTANT + COEFF1 * FAS_TOTAL_NORMED_ZSCORE_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	(FAS_LANG = 1 or 2)	Regression-based predicted FAS_TOTAL score (using participant's normed Z-scores and time interval between tests)

Derived Variable Specifications:

Value	Condition(s)	Description
(FAS_TOTAL_NORMED_ZSCORE_COF1 – FAS_FU1_pred) / SD_residual where *SD*_RESID is the standard deviation of the residuals (observed - predicted) (obtained from the neuro-healthy norming sample)	(FAS_LANG = 1 or 2)	The standardized difference between the participant's observed and predicted FU1 scores.

15. FAS TOTAL Reliable Change Indicator (RCI)

Derived Variable Name: FAS_TOTAL_RCI_COF1

Description: This variable is a recoding of FAS_TOTAL_CHNG_ZSCORE_COF1 into one of three categories indicating the participant's change in performance since baseline: declined (-1), remained stable (0), or improved (+1) over time. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_FAS_CHNG_ZSCORE_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	FAS_TOTAL_CHNG_ZSCORE_COF1 < -1.645	On FAS, participant's performance at follow-up declined since baseline.
0	FAS_TOTAL_CHNG_ZSCORE_COF1 ≥ -1.645 and FAS_TOTAL_CHNG_ZSCORE_COF1 < +1.645	On FAS, participant's performance at follow-remained stable compared with baseline.
+1	FAS_TOTAL_CHNG_ZSCORE_COF1 > +1.645	On FAS, participant's performance at follow-up improved since baseline.

16. Temporary Language Variable

Derived Variable Name: ALL7_LANG

Description: A single language variable, ALL7_LANG, is created for coding English or French test administration at baseline and at follow-up. It uses the temporary variables for language of administration created for the individual tests described above.

Based on:
REYI_LANG, REYII_LANG, AFT_LANG, MAT_LANG, STP_LANG, FAS_LANG,

Derived Variable Specifications:

Value	Condition(s)	Description
ALL7_LANG = 1	REYI_LANG = 'en' and REYII_LANG = 'en' and AFT_LANG = 'en' and MAT_LANG = 'en' and STP_LANG = 'en' and FAS_LANG = 'en'	Language of administration of all tests at both baseline and FU1 is English
ALL7_LANG = 2	REYI_LANG = 'fr' and REYII_LANG = 'fr' and AFT_LANG = 'fr' and MAT_LANG = 'fr' and STP_LANG = 'fr' and FAS_LANG = 'fr'	Language of administration of all tests at both baseline and FU1 is French
.	The conditions above were not met.	Language variables are missing or inconsistent

17. Memory Composite (MEM) Reliable Change Z-score

Derived Variable Name: COG_CONSTR_MEM_CHNG_COF1

Description: This variable indicates the participant's change in performance on memory, a latent variable constructed from REY I and REY II scores normed for age, sex and education level. It is based on the change in the constructed memory latent variables from baseline to the first follow-up. The memory change score is a z-score, standardized relative to the neuro-healthy norming sample (separately for English and French). It is only available for participants who have normed scores on Rey I and Rey II at both baseline and follow-up.

Based on:

COG_CONSTR_MEM_COM, COG_CONSTR_MEM_COF1, delta_T_months

ALL7_LANG

Temporary Variable: The variable, MEM_FU1_pred, is the participant's predicted memory score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

MEM_FU1_pred = CONSTANT + COEFF1 * COG_CONSTR_MEM_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	Regression-based predicted MEM score

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_CONSTR_MEM_COF1 – MEM_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

18. Memory Composite (MEM) Reliable Change Indicator (RCI)

Derived Variable Name: COG_CONSTR_MEM_RCI_COF1

Description: This variable is a recoding of COG_CONSTR_MEM_CHNG_COF1 into one of three categories indicating the participant's change since baseline: declined (-1), remained stable (0), or improved (+1) over time. The recoding is language invariant. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_CONSTR_MEM_CHNG_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_CONSTR_MEM_CHNG_COF1 < -1.645	Participant's memory performance at follow-up declined since baseline.
0	COG_CONSTR_MEM_CHNG_COF1 ≥ -1.645 and COG_CONSTR_MEM_CHNG_COF1 < 1.645	Participant's memory performance at follow-up remained stable compared with baseline.
+1	COG_CONSTR_MEM_CHNG_COF1 ≥ 1.645	Participant's memory performance at follow-up improved since baseline.

19. Executive Function (EF2) Composite Reliable Change Z-score, based on AF2 and MAT only

Derived Variable Name: COG_CONSTR_EF2_CHNG_COF1

Description: This variable indicates the participant's change in performance on executive function, based on the two tests in common with the Tracking cohort. EF2 is a latent variable constructed from AF2 and MAT scores normed for age, sex and education level. It is based on the change in the constructed executive function latent variables from baseline to the first follow-up. The executive function change score is a z-score, standardized relative to the neuro-healthy norming sample (separately for English and French). It is only available for participants who have normed scores on the AFT and MAT at both baseline and follow-up.

Based on:
COG_CONSTR_EF2_COM, COG_CONSTR_EF2_COF1, delta_T_months,
ALL7_LANG

Temporary Variable: The variable, EF2_FU1_pred, is the participant's predicted executive function score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

EF2_FU1_pred = CONSTANT + COEFF1 * COG_CONSTR_EF2_COM + COEFF2 * delta_T_months, Where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	Regression-based predicted EF2 score

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_CONSTR_EF2_COF1 – EF2_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

20. Executive Function (EF2) Reliable Change Indicator (RCI), based on AF2 and MAT only

Derived Variable Name: COG_CONSTR_EF2_RCI_COF1

Description: This variable is a recoding of COG_CONSTR_EF2_CHNG_COF1 into one of three categories indicating the participant's change since baseline: declined (-1), remained stable (0), or improved (+1) over time. The recoding is language invariant. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_CONSTR_EF2_CHNG_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_CONSTR_EF2_CHNG_COF1 < -1.645	Participant's executive function performance at follow-up declined since baseline.
0	COG_CONSTR_EF2_CHNG_COF1 ≥ -1.645 and COG_CONSTR_EF2_CHNG_COF1 < 1.645	Participant's executive function performance at follow-up remained stable compared with baseline.
+1	COG_CONSTR_EF2_CHNG_COF1 ≥ 1.645	Participant's executive function performance at follow-up improved since baseline.

21. Executive Function (EF4) Composite Reliable Change Z-score, based on AF2, MAT, STP_RATIO and FAS_TOTAL

Derived Variable Name: COG_CONSTR_EF4_CHNG_COF1

Description: This variable indicates the participant's change in performance on executive function, based on all tests in the Comprehensive battery. EF4 is a latent variable constructed from AF2, MAT, STP_RATIO and FAS_TOTAL scores normed for age, sex and education level. It is based on the change in the constructed executive function latent variables from baseline to the first follow-up. The executive function change score is a z-score, standardized relative to the neuro-healthy norming sample (separately for English and French). It is only available for participants who have normed scores on all tests at both baseline and follow-up.

Based on:

COG_CONSTR_EF4_COM, COG_CONSTR_EF4_COF1, delta_T_months,

ALL7_LANG

Temporary Variable: The variable, EF4_FU1_pred, is the participant's predicted executive function score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

EF4_FU1_pred = CONSTANT + COEFF1 * COG_CONSTR_EF4_COM + COEFF2 * delta_T_months, Where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	Regression-based predicted EF4 score

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_CONSTR_EF4_COF1 – EF4_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

22. Executive Function (EF4) Reliable Change Indicator (RCI), based on AF2, MAT, STP_RATIO and FAS_TOTAL

Derived Variable Name: COG_CONSTR_EF4_RCI_COF1

Description: This variable is a recoding of COG_CONSTR_EF4_CHNG_COF1 into one of three categories indicating the participant's change since baseline: declined (-1), remained stable (0), or improved (+1) over time. The recoding is language invariant. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_CONSTR_EF4_CHNG_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_CONSTR_EF4_CHNG_COF1 < -1.645	Participant's executive function performance at follow-up declined since baseline.
0	COG_CONSTR_EF4_CHNG_COF1 ≥ -1.645 and COG_CONSTR_EF4_CHNG_COF1 < 1.645	Participant's executive function performance at follow-up remained stable compared with baseline.
+1	COG_CONSTR_EF4_CHNG_COF1 ≥ 1.645	Participant's executive function performance at follow-up improved since baseline.

23. Overall Cognition (OVERALLCOG4) Composite Reliable Change Z-score, based on tests in common with the Tracking battery

Derived Variable Name: COG_CONSTR_OVERALLCOG4_CHNG_COF1

Description: This variable indicates the participant's change in performance on overall cognition, a latent variable constructed from the four test scores in common with the Tracking cohort, normed for age, sex and education level. It is based on the change in the constructed overall cognition latent variables from baseline to the first follow-up. The change score is a z-score, standardized relative to the neuro-healthy norming sample (separately for English and

French). It is only available for participants who have normed scores on the all four tests at both baseline and follow-up.

Based on:

COG_CONSTR_OVERALLCOG4_COM,	COG_CONSTR_OVERALLCOG4_COF1,
delta_T_months	ALL7_LANG

Temporary Variables: The variable, OVERALL4_FU1_pred, is the participant's predicted overall cognition score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

OVERALL4_FU1_pred = CONSTANT + COEFF1 * COG_CONSTR_OVERALLCOG4_COM + COEFF2 * delta_T_months, Where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	Regression-based predicted overall cognition score

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_CONSTR_OVERALLCOG4_COF1 – OVERALL4_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

24. Overall Cognition (OVERALLCOG4) Reliable Change Indicator (RCI), based on a composite score of tests in common with the Tracking battery

Derived Variable Name: COG_CONSTR_OVERALLCOG4_RCI_COF1

Description: This variable is a recoding of COG_CONSTR_OVERALLCOG4_CHNG_COF1 into one of three categories indicating the participant's change since baseline: declined (-1), remained stable (0), or improved (+1) over time. The recoding is language invariant. (Note: the convention in reliable change indices is to use a cut-off of z=1.645. You can apply any cut-off you wish and create your own three groups. When we analyze reliable change indices across a neuropsychological battery (i.e., did cognition improve, stay the same, or decline overall) we adjust for the frequency of change scores, which helps to offset this more lenient cut-off applied at the level of the individual test score).

Based on: COG_CONSTR_OVERALLCOG4_CHNG_COF1

Derived Variable Specifications:

Value	Condition(s)	Description
-1	COG_CONSTR_OVERALLCOG4_CHNG_COF1 < -1.645	Participant's overall cognition at follow-up declined since baseline.
0	COG_CONSTR_OVERALLCOG4_CHNG_COF1 ≥ -1.645 and COG_CONSTR_OVERALLCOG4_CHNG_COF1 < 1.645	Participant's overall cognition at follow-up remained stable compared with baseline.
+1	COG_CONSTR_OVERALLCOG4_CHNG_COF1 ≥ 1.645	Participant's overall cognition at follow-up improved since baseline.

25. Overall Cognition (OVERALLCOG6) Composite Reliable Change Z-score, based on a composite score of all 6 in the Comprehensive battery

Derived Variable Name: COG_CONSTR_OVERALLCOG6_CHNG_COF1

Description: This variable indicates the participant's change in performance on overall cognition, a latent variable constructed from all test scores normed for age, sex and education level. It is based on the change in the constructed overall cognition latent variables from baseline to the first follow-up. The change score is a z-score, standardized relative to the neuro-healthy norming sample (separately for English and French). It is only available for participants who have normed scores on the all four tests at both baseline and follow-up.

Based on:

COG_CONSTR_OVERALLCOG6_COM,	COG_CONSTR_OVERALLCOG6_COF1,
delta_T_months	ALL7_LANG

Temporary Variable: The variable, OVERALL6_FU1_pred, is the participant's predicted overall cognition score based on her/his language of administration, baseline test score and time interval between testing. These variables are not included in the CLSA dataset but the procedures are included to detail the steps used in derivation.

OVERALL_FU1_pred = CONSTANT + COEFF1 * COG_CONSTR_OVERALLCOG_COM + COEFF2 * delta_T_months, where CONSTANT, COEFF1 and COEFF2 are estimates from linear regression models obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	Regression-based predicted overall cognition score

Derived Variable Specifications:

Value	Condition(s)	Description
(COG_CONSTR_OVERALLCOG_COF1 – OVERALL_FU1_pred) / SD_residual where SD_RESID is the standard deviation of the residuals (predicted – observed) obtained from the neuro-healthy norming sample	ALL7_LANG = 1 or 2	The standardized difference between the participant's observed and predicted FU1 scores.

References:

O'Connell, M. E., Kadlec, H., Griffith, L. E., Wolfson, C., Maimon, G., Taler, V., Kirkland, S., Raina, P. (submitted). Cognitive impairment indicator for the neuropsychological test batteries in the Canadian Longitudinal Study on Aging: Definition and evidence for validity. *Alzheimer's Research & Therapy*.

O'Connell, M. E., Kadlec, H., Maimon, G., Taler, V., Simard, M., Griffith, L., Tuokko, H., Voll, S., Wolfson, C., Kirkland, S., & Raina, P. (2021). Methodological considerations when establishing reliable and valid normative data: Canadian Longitudinal Study on Aging (CLSA) neuropsychological battery. The Clinical Neuropsychologist. https://doi.org/10.1080/13854046.2021.1954243

O'Connell, M. E., Kadlec, H., Taler, V., Gicas, K., Griffith, L., Wolfson, C., Kirkland, S., & Raina, P. (2022). Cognitive impairment indicator for the CLSA: Incorporating reliable change indices and a base rates. International Neuropsychological Society Mid-Year Meeting, 2022, Barcelona, July 6-8, 2022.