Appendix 1. Steps of development of computerized adaptive testing

In general, a computerized adaptive testing (CAT) is developed through 5 stages: (1) Development of an item pool, (2) Field testing of the item pool, (3) Establishment of a calibrated item bank, (4) Simulation study to determine a set of stopping rules, and (5) Development of an administration platform of the CAT.

(1) Development of an item pool.

CAT developers have to establish a pool of items by designing new items or selecting items from existing tests/scales. The item pool should include items with varied difficulty for examinees.

(2) Field testing of the item pool.

CAT developers administer the item pool to target subjects with sufficient sample size, and the subjects' level of function (or ability) should range from low to high.

(3) Establishment of a calibrated item bank.

CAT developers analyze the data of field testing using IRT software to obtain the fitness and calibrated item parameters of each item in the item pool. Thereafter, CAT developers remove the items with poor fitness from the item pool and retain or select partial items with varied item parameters to establish the calibrated item bank of the CAT.

(4) Simulation study to determine a set of stopping rules

CAT developers conduct a simulation study to explore the CAT's performance (reliability and number of items administered) when the CAT adopts different sets of stopping rules. In general, the larger the number of items administered in a CAT, the higher the reliability. Therefore, CAT developers should determine a set of stopping rules with optimal balance between the reliability and the number of items administered.

(5) Development of an administration platform of CAT

CAT developers should develop a website/software/APP for administering the CAT to improve the accessibility for users.

Appendix 2. Data retrieval of the CAT-FAS study

The FAS study

Administration

- Fugl-Meyer Assessment
- Postural Assessment Scale for Stroke patients
- Barthel Index

301 patients

Rasch analysis

Results of Rasch analysis

A) Item bank (58 Items fit to the Rasch partial credit model)				B) Responses to the fitted items of the item bank		
Domain of the items	Item ID	Content	Item difficulty	Patient ID: 1	...	301
UE motor function (26 items)	1	Protracts scapula in supine	-4.3	2	...	1
	...	...	...	...	...	...
	26	...	...	...	...	...
LE motor function (11 items)	27	Flexes hip and knee in supine	-2.7	2	...	1
	...	...	...	...	...	...
	37	...	...	...	...	...
Postural control (12 items)	38	Sitting without support	-2.5	3	...	2
	...	...	...	...	...	...
	49	...	...	...	...	...
Basic activities of daily living (9 items)	50	Bathing	3.1	1	...	0
	...	...	...	...	...	...
	58	...	...	...	...	...

	C) The scores of the patients in the 4 functions (Rasch score)		
UE motor function	1.0	...	-6.3
LE motor function	6.0	...	-2.1
Postural control	5.0	...	-1.2
Basic activities of daily living	1.1	...	-2.0

Data retrieval

The CAT-FAS study

Results of IRT analysis

A) Item bank (58 Items fit to the Rasch partial credit model)				B) Responses to the fitted items of the item bank		
Domain of the items	Item ID	Content	Item difficulty	Patient ID: 1	...	301
UE motor function (26 items)	1	Protracts scapula in supine	-4.3	2	...	1
	...	...	...	...	...	...
	26	...	...	...	...	...
LE motor function (11 items)	27	Flexes hip and knee in supine	-2.7	2	...	1
	...	...	...	...	...	...
	37	...	...	...	...	...
Postural control (12 items)	38	Sitting without support	-2.5	3	...	2
	...	...	...	...	...	...
	49	...	...	...	...	...
Basic activities of daily living (9 items)	50	Bathing	3.1	1	...	0
	...	...	...	...	...	...
	58	...	...	...	...	...

	C) The scores of the patients in the 4 functions (Rasch score)		
UE motor function	1.0	...	-6.3
LE motor function	6.0	...	-2.1
Postural control	5.0	...	-1.2
Basic activities of daily living	1.1	...	-2.0

Appendix 3. Fugl-Meyer Assessment

Fugl-Meyer Motor Assessment_U/E & L/E

◎**Upper Extremity**

A. SHOULDER/ELBOW/FOREARM

1. Reflex-activity	a	Flexors	0		2
	b	Extensors	0		2
2. a. flexor synergy					
Shoulder		Retraction	0	1	2
		Elevation	0	1	2
		Abduction	0	1	2
		Outwards rotation	0	1	2
Elbow		Flexion	0	1	2
Forearm		Supination	0	1	2
b. extensor synergy					
Shoulder		Add-/Inw. rotation	0	1	2
Elbow		Extension	0	1	2
Forearm		Pronation	0	1	2
3. Hand to lumbar spine			0	1	2
Shoulder		Flexion 0-90	0	1	2
Elbow 90		Pro-/Supination	0	1	2
4. Shoulder		Abduction 0-90	0	1	2
		Flexion 90-180	0	1	2
Elbow 0		Pro-/Supination	0	1	2
5. Normal reflex-activity	a	Flexors/ Extensors	0	1	2

B. WRIST

1. Elbow 90		Wrist-stability	0	1	2
		Wrist-flexion/extension	0	1	2
2. Elbow 0		Wrist-stability	0	1	2
		Wrist-flexion/extension	0	1	2
Circumduction			0	1	2

C. HAND

1. Finger		Mass flexion	0	1	2
		Mass extension	0	1	2
2. Grasp	a	MP joints extended, PIPs & DIPs flexed; grasp is tested against resistance	0	1	2
	b	Patient is instructed to adduct thumb, all other joints at 0	0	1	2

	c	Opposes thumb pad of index finger; a pencil is interposed	0	1	2
	d	Patient grasps a cylinder-shaped object (small can), with the volar surfaces of the first and second fingers against each other	0	1	2
	e	A spherical grasp; patient grasps a tennis ball	0	1	2

D. COORDINATION/SPEED

Finger to nose (5 repetitions)		Tremor	0	1	2
		Dysmetria	0	1	2
		Time	0	1	2

◎LOWER EXTREMITY

E. HIP/KNEE/ANKLE

1. Reflex-activity		Flexors	0		2
		Extensors	0		2
2. a. flexor synergy					
Hip		Flexion	0	1	2
Knee		Flexion	0	1	2
Ankle		Dorsi-flexion	0	1	2
b. extensor synergy					
Hip		Extension	0	1	2
		Adduction	0	1	2
Knee		Extension	0	1	2
Ankle		Plantar flexion	0	1	2
3. Knee (sitting)		Flexion	0	1	2
Ankle		Dorsi-flexion	0	1	2
4. Knee (standing)		Flexion	0	1	2
Ankle		Dorsi-flexion	0	1	2
5. Normal reflex-activity		Flexors/ Extensors	0	1	2

F. COORDINATION/SPEED

Heel to opposite knee (5 repetitions)		Tremor	0	1	2
		Dysmetria	0	1	2
		Time	0	1	2

Fugl-Meyer, A. R., Jaasko, L., Leyman, I., Olsson, S. & Steglind, S. The post-stroke hemiplegic patient 1: A method for evaluation of physical performance. *Scandinavian Journal of Rehabilitation Medicine.* **7** (1), 13-31, (1975).

Appendix 4. Postural Assessment Scale for Stroke patients

Postural Assessment Scale for Stroke patients

Maintaining a Posture				
1. Sitting without support (sitting on the edge of an 50-cm-high examination table [a Bobath plane, for instance] with the feet touching the floor)	0 cannot sit	1 can sit with slight support, for example, by one hand	2 can sit for more than 10 seconds without support	3 can sit for 5 minutes without support
2. Standing with support (feet position free, no other constrains)	0 cannot stand, even with support	1 can stand with strong support of 2 people	2 can stand with moderate support of 1 people	3 can stand with support of only 1 hand
3. Standing without support (feet position free, no other constraints)	0 cannot stand without support	1 can stand without support for 10 seconds or leans heavily on I leg	2 can stand without support for I minute or stands slightly asymmetrically	3 can stand without support for more than I minute and at the same time perform arm movements above the shoulder level
4. Standing on nonparetic leg (no other constraints)	0 cannot stand on nonparetic leg	1 can stand on nonparetic leg for a few seconds	2 can stand on nonparetic leg for more than 5 seconds	3 can stand on nonparetic leg for more than 10 seconds
5. Standing on paretic leg (no other constraints)	0 cannot stand on paretic leg	1 can stand on paretic leg for a few seconds	2 can stand on paretic leg for more than 5 seconds	3 can stand on paretic leg for more than 10 seconds
B. Changing Posture Scoring of items 6 to 12 is as follows (items 6 to 11 are to be performed with a 50-cm-high examination table, like a Bobath plane; items 10 to 12 are to be performed without any support; no other constraints):				
	cannot perform the activity	can perform the activity with much help	can perform the activity with little help	can perform the activity without help
6. Supine to affected side lateral	0	1	2	3
7. Supine to nonaffected side lateral	0	1	2	3
8. Supine to sitting up on the edge of the table	0	1	2	3
9. Sitting on the edge of the table to supine	0	1	2	3
10. Sitting to standing up	0	1	2	3
11. Standing up to sitting down	0	1	2	3
12. Standing, picking up a pencil from the floor	0	1	2	3

Benaim, C., Perennou, D. A., Villy, J., Rousseaux, M. & Pelissier, J. Y. Validation of a standardized assessment of postural control in stroke patients: The Postural Assessment Scale for Stroke Patients (PASS). *Stroke.* **30** (9), 1862-1868, (1999).

Appendix 5. Barthel Index

Barthel Index

Instructions: Choose the scoring point for the statement that most closely corresponds to the patient's current level of ability for each of the following 10 items. Record actual, not potential, functioning. Information can be obtained from the patient's self-report, from a separate party who is familiar with the patient's abilities (such as a relative), or from observation. Refer to the Guidelines section on the following page for detailed information on scoring and interpretation.

Bowels
0 = incontinent (or needs to be given enemata)
1 = occasional accident (once/week)
2 = continent
Patient's Score: _____

Bladder
0 = incontinent, or catheterized and unable to manage
1 = occasional accident (max. once per 24 hours)
2 = continent (for over 7 days)
Patient's Score: _____

Grooming
0 = needs help with personal care
1 = independent face/hair/teeth/shaving (implements provided)
Patient's Score: _____

Toilet use
0 = dependent
1 = needs some help, but can do something alone
2 = independent (on and off, dressing, wiping)
Patient's Score: _____

Feeding
0 = unable
1 = needs help cutting, spreading butter, etc.
2 = independent (food provided within reach)
Patient's Score: _____

(Collin et al., 1988)

Transfer
0 = unable – no sitting balance
1 = major help (one or two people, physical), can sit
2 = minor help (verbal or physical)
3 = independent
Patient's Score: _____

Mobility
0 = immobile
1 = wheelchair independent, including corners, etc.
2 = walks with help of one person (verbal or physical)
3 = independent (but may use any aid, e.g., stick)
Patient's Score: _____

Dressing
0 = dependent
1 = needs help, but can do about half unaided
2 = independent (including buttons, zips, laces, etc.)
Patient's Score: _____

Stairs
0 = unable
1 = needs help (verbal, physical, carrying aid)
2 = independent up and down
Patient's Score: _____

Bathing
0 = dependent
1 = independent (or in shower)
Patient's Score: _____

Total Score: _____

Scoring:

Sum the patient's scores for each item. Total possible scores range from 0 – 20, with lower scores indicating increased disability. If used to measure improvement after rehabilitation, changes of more than two points in the total score reflect a probable genuine change, and change on one item from fully dependent to independent is also likely to be reliable.

Sources:

- Collin C, Wade DT, Davies S, Horne V. The Barthel ADL Index: a reliability study. *Int Disabil Stud*. 1988;10(2):61-63.
- Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J*. 1965;14:61-65.
- Wade DT, Collin C. The Barthel ADL Index: a standard measure of physical disability? *Int Disabil Stud*. 1988;10(2):64-67.

Appendix 6. The 58 items of the CAT-FAS

Item of the CAT-FAS
FM-UE subset
1. Shoulder retraction
2. Shoulder elevation
3. Shoulder abduction
4. Shoulder external rotation
5. Elbow flexion
6. Forearm supination
7. Shoulder adduction/internal rotation
8. Elbow extension
9. Forearm pronation
10. Hand to lumbar spine
11. Shoulder flexion 0° to 90°
12. Elbow 90° pronation/supination
13. Shoulder abduction 0° to 90°
14. Shoulder flexion 90° to 180°
15. Elbow 0° pronation/supination
16. Elbow 90° wrist stability
17. Elbow 90° wrist flexion/extension
18. Elbow 0° wrist stability
19. Elbow 0° wrist flexion/extension
20. Circumduction
21. Hand, mass extension
22. Hook grasp
23. Lateral prehension
24. Palmar prehension
25. Cylinder grip
26. Spherical grip
FM-LE subset
27. Hip flexion, supine
28. Knee flexion, supine
29. Hip extension, supine
30. Hip adduction, supine
31. Knee extension, supine
32. Ankle plantar flexion, supine
33. Knee flexion, sitting
34. Ankle dorsiflexion, sitting

35. Knee flexion to 90°, standing
36. Ankle dorsiflexion, standing
37. Heel to opposite knee, time

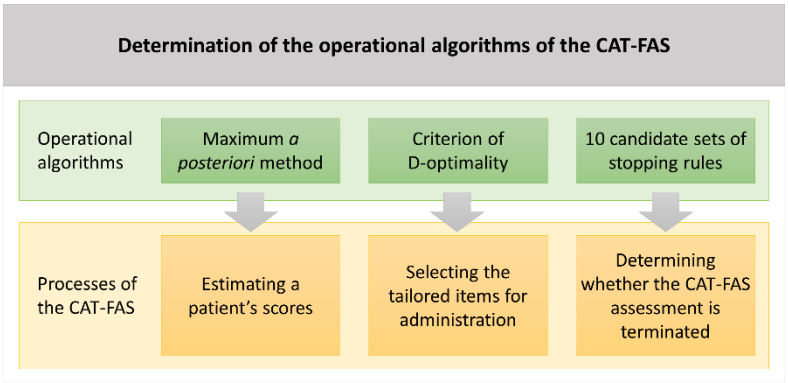
PASS subset

38. Sitting without support
39. Standing with support
40. Standing without support
41. Standing on unaffected leg
42. Standing on paretic leg
43. Supine to affected side lateral
44. Supine to unaffected side lateral
45. Supine to sitting up on the edge of the table
46. Sitting on the edge of the table to supine
47. Sitting to standing up
48. Standing up to sitting down
49. Standing, picking up a pencil from floor

BI subset

50. Bathing
51. Grooming
52. Dressing
53. Bowels
54. Bladder
55. Toilet use
56. Transfers
57. Mobility
58. Stairs

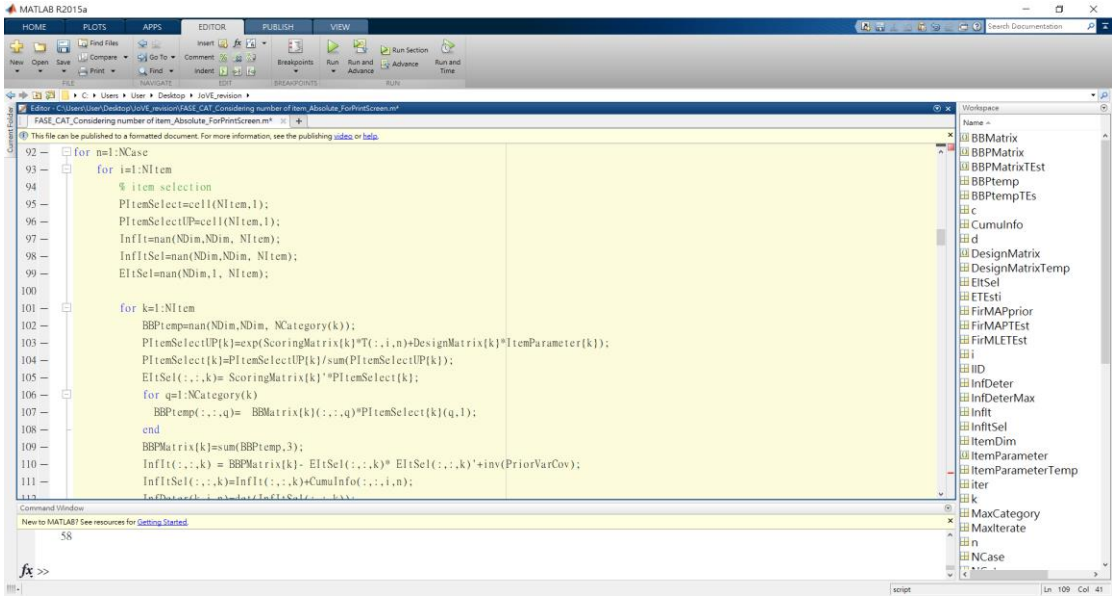
Appendix 7. Determination of the operational algorithms of the CAT-FAS



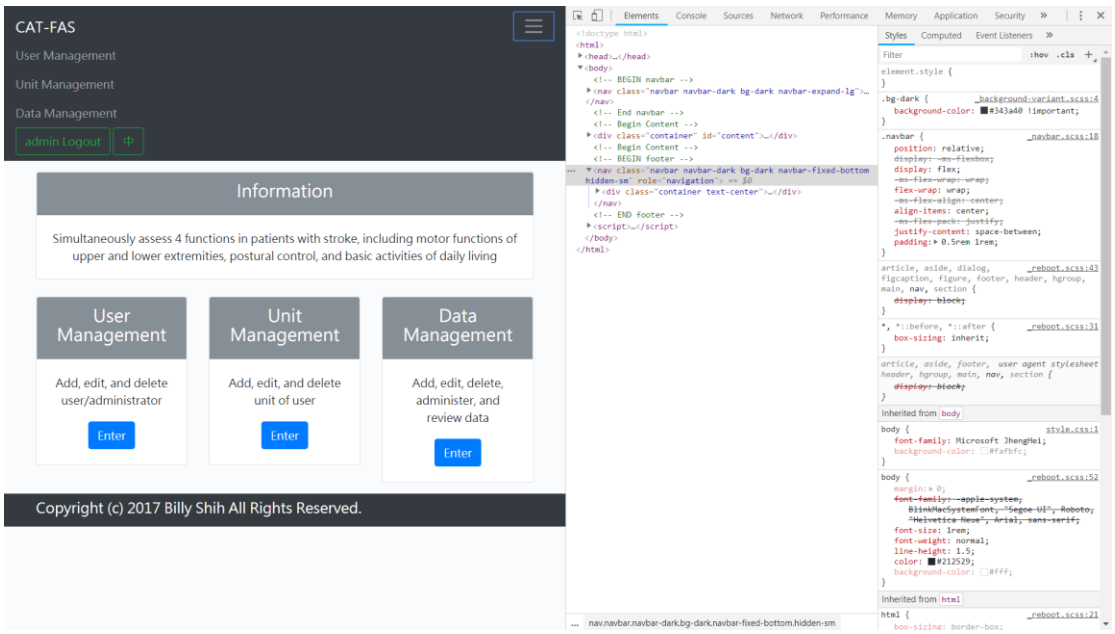
Appendix 8. 10 candidate sets of stopping rules

10 candidate sets of stopping rules	
Reaching limited reliability increase (LRI) criterion	
1	LRI < 0.001
2	LRI < 0.005
3	LRI < 0.010
4	LRI < 0.015
5	LRI < 0.020
Reaching either LRI criterion or threshold of reliability	
6	LRI < 0.001 or Rasch reliability ≥ 0.90
7	LRI < 0.005 or Rasch reliability ≥ 0.90
8	LRI < 0.010 or Rasch reliability ≥ 0.90
9	LRI < 0.015 or Rasch reliability ≥ 0.90
10	LRI < 0.020 or Rasch reliability ≥ 0.90

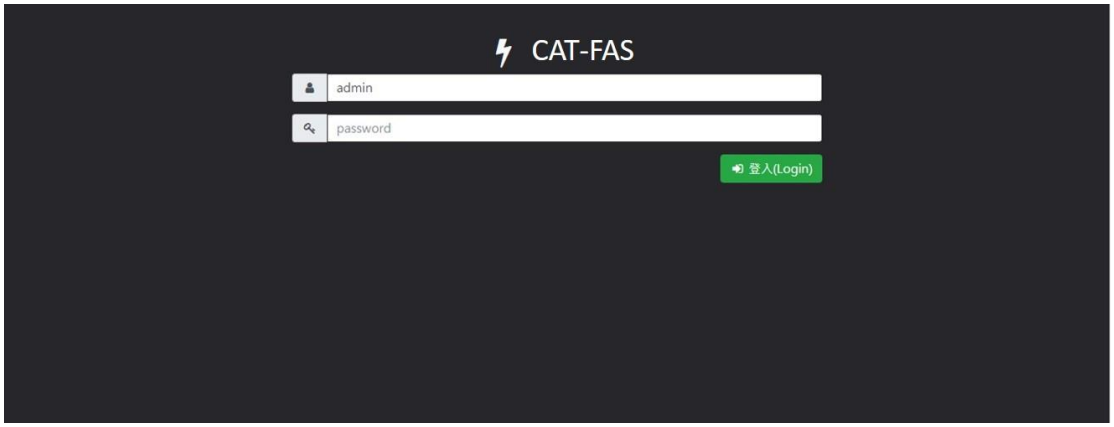
Appendix 9. Screenshot of the software conducting simulation of the CAT-FAS



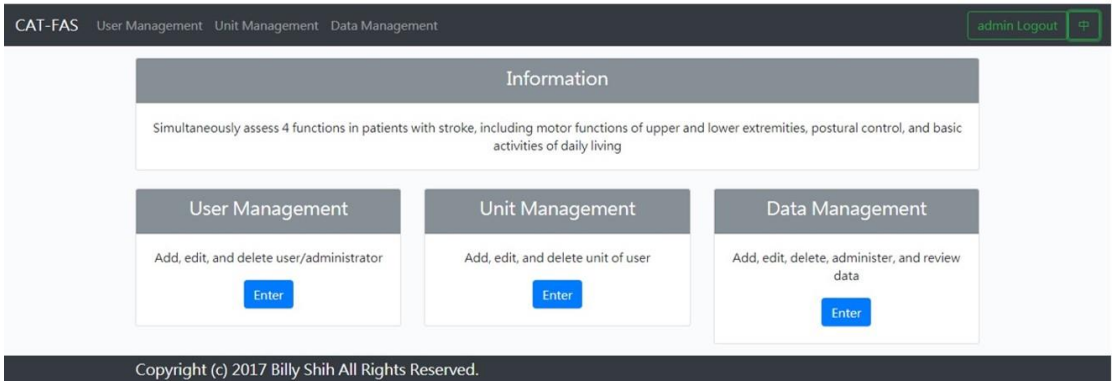
Appendix 10. Screenshot of the development of the online administration platform of the CAT-FAS



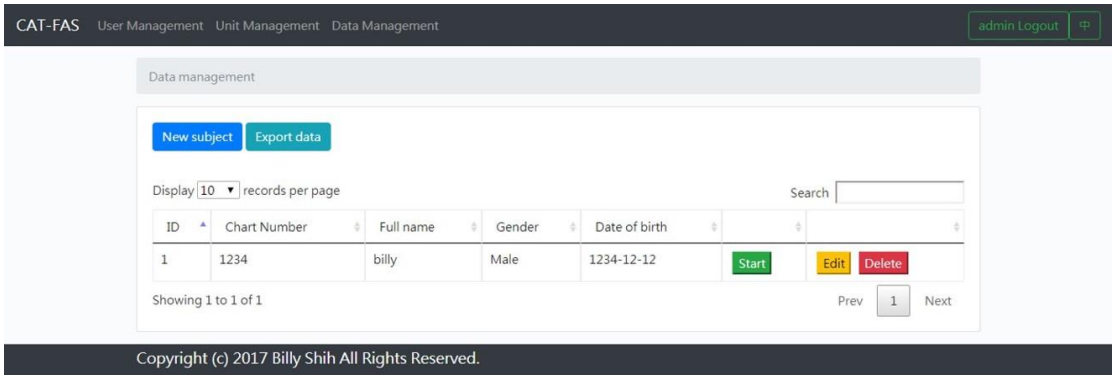
Appendix 11. Login page of the CAT-FAS



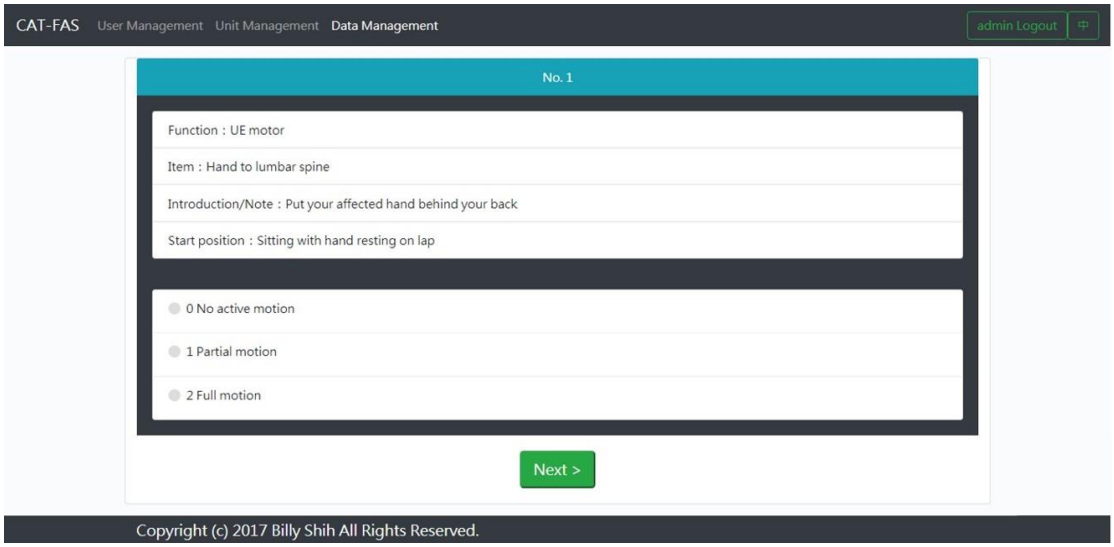
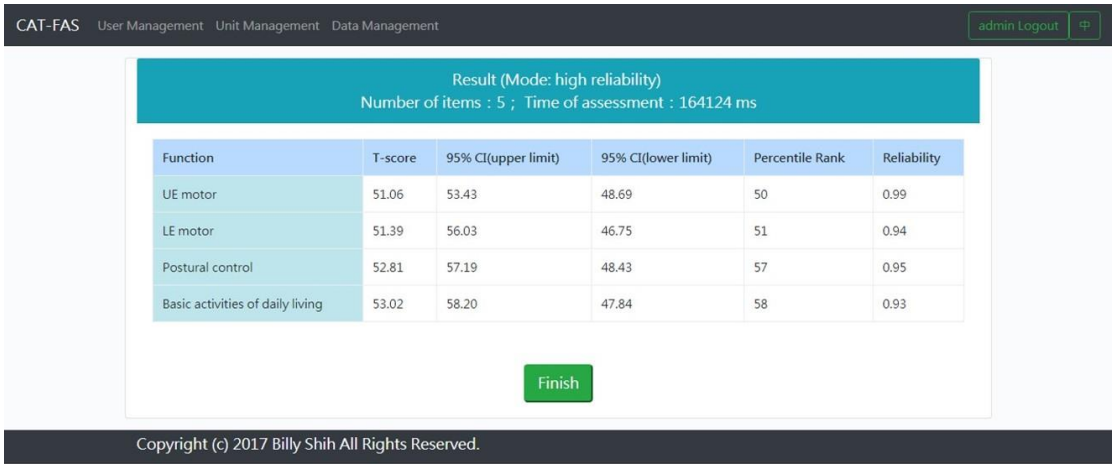
Appendix 12. Home page of the CAT-FAS



Appendix 13. Data management page of the CAT-FAS



Appendix 14. Example of an item of the CAT-FAS



Appendix 15. Results of the CAT-FAS administration