



Physiological Indicators of Skill Acquisition

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Behavioral measures do not allow an instructor to look inside the student's head

- Assumed key facet of expertise involves efficient utilization of cognitive and physiological resources
- Cannot recognize situations where:
 - Student attains criteria level of performance, yet must muster every available resource to do what experts accomplish with ease
 - Student goes through the motions, but has become frustrated and psychologically given up

		Student	
		Aroused	Not Aroused
Expert	Aroused	Good	Don't understand Given up
	Not Aroused	Struggling, despite performance	Good





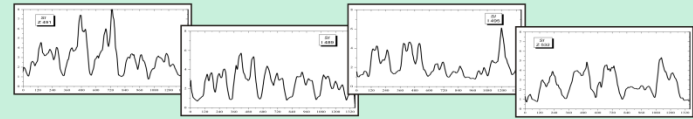
Objective system utilizes physiological measures as basis for assessing skill acquisition

Physiological State Assessor

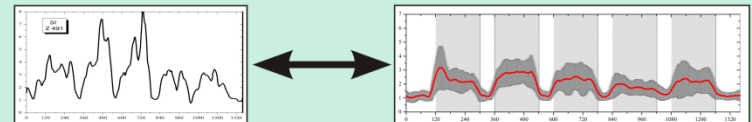
algorithms of HRV-analysis



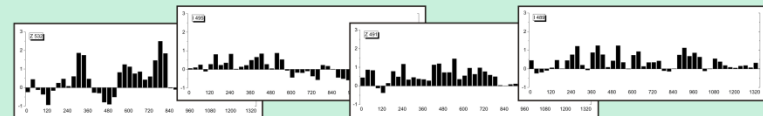
Student physiological response profiles



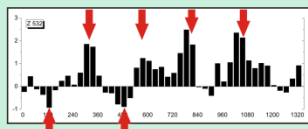
Comparison with the expert model



Assessment of students' physiological response



Identification of individual deficiencies

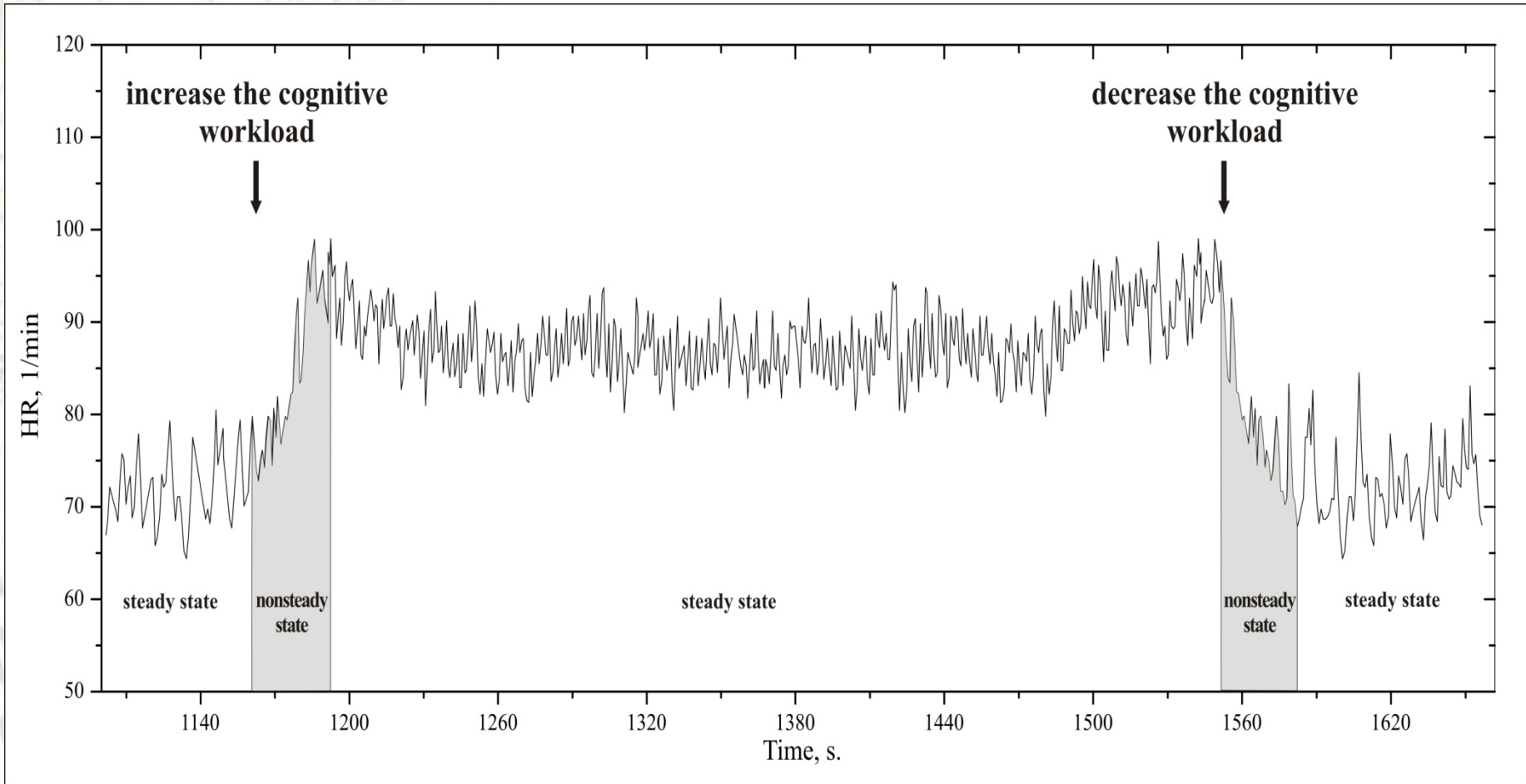


The development of individual training program



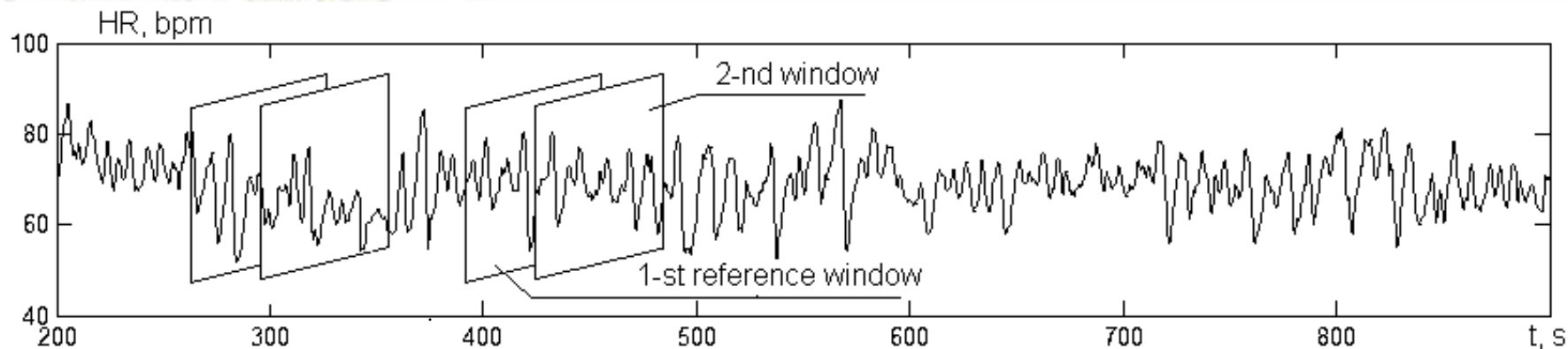


Non-stationary phases in instantaneous heart rate dynamics indicate cognitive load





Approach using time windows in calculating Non-stationary Index (NI) provides time sensitive measure



NI is based on the comparison of four HR characteristics, including mean value, standard deviation, linear trend slope, prediction error of autoregressive model and is calculated by the formula:

$$NI = |RRNN_1 - RRNN_2| \cdot |SDNN_1 - SDNN_2| \cdot SL_1 \cdot ER_{1,2}$$

Where RRNN – mean RR interval for the set window;

SDNN – standard deviation of RR intervals for the set window;

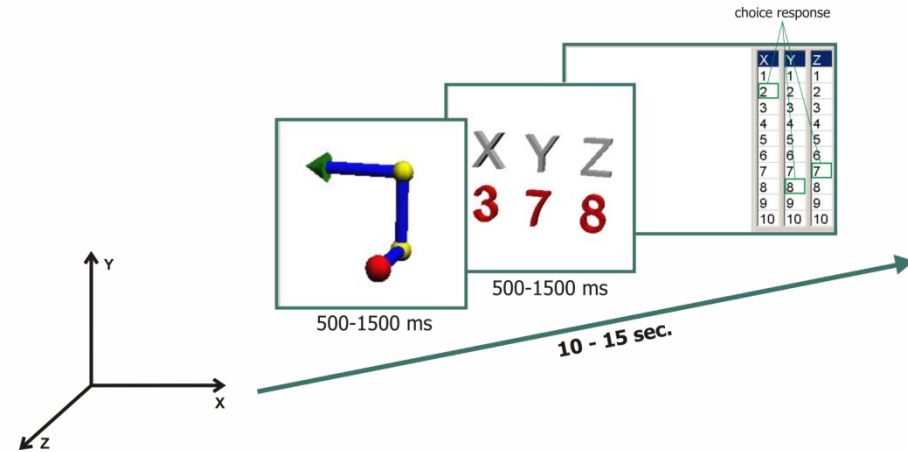
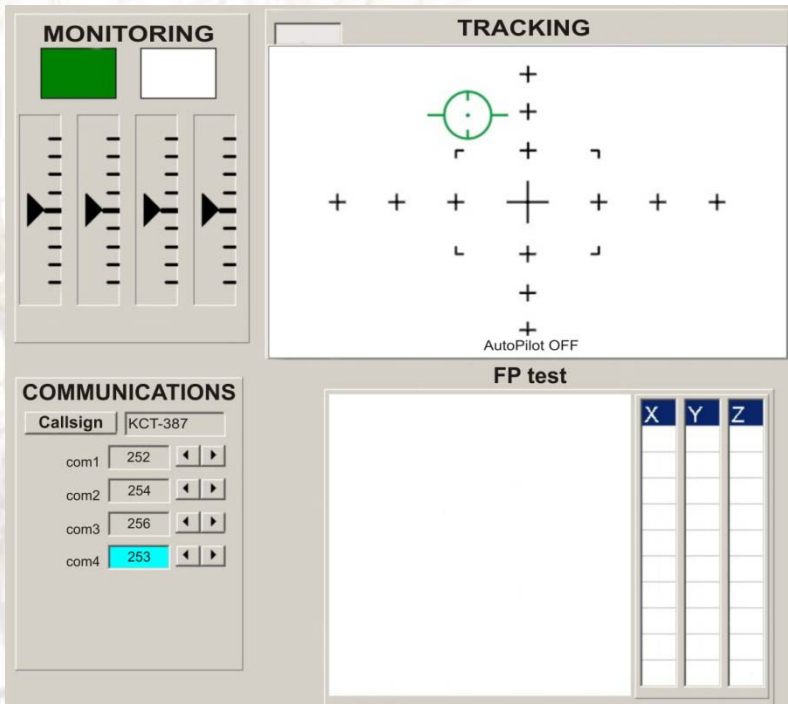
SL – angle of slope of a HR-signal linear approximation,

ER – prediction error of the tenth-order autoregressive (AR) model

1, 2 – window number.



Task combined Multi-Attribute Test Battery (MATB) with Flight Path Test



Participants shown a “flight path” trajectory in 3D coordinates and must estimate the coordinates of the final “flight path”

Monitoring - visual monitoring of warning lights and dials

Tracking - track an unstable target using a joystick

Communications – must keep information about six-digit call-sign in verbal working memory



Subjects presented five conditions involving different task combinations

Task	Description	Cognitive processing bottlenecks / executive functions	Duration, sec.
A	Monitoring & FPT	sensory bottleneck, peripheral visual attention, task set shifting	180
B	Tracking & FPT	visiospatial working memory bottleneck, resistance to visiospatial distractors	180
C	Communication & FPT	verbal working memory bottleneck, interference control, resistance to verbal distractors	180
D	Complicated FPT under time pressure	working memory capacity, visiospatial perceptual speed	180
E	Monitoring, Tracking & Communication	mental set shifting, information updating, inhibition of prepotent responses	180





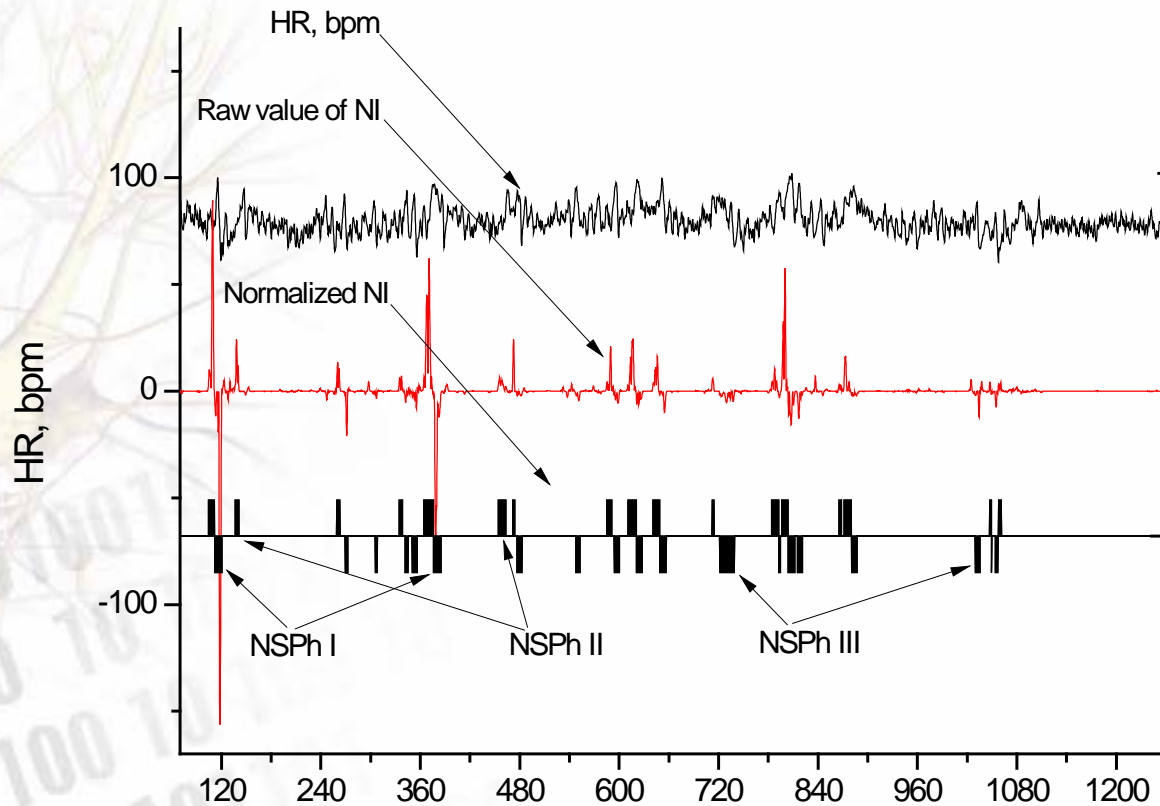
Hypothesized that physiological profile of less adept subjects would approximate experts as they gained proficiency

- N=50, university students
- Subjects assigned to expert and student groups using baseline performance
- Students received additional training and a follow-up performance assessment





Algorithms detected nonstationary fragments characterized by sharp changes of heart rate parameters



Three types of Non-Stationary Phases (NSPh) were used.

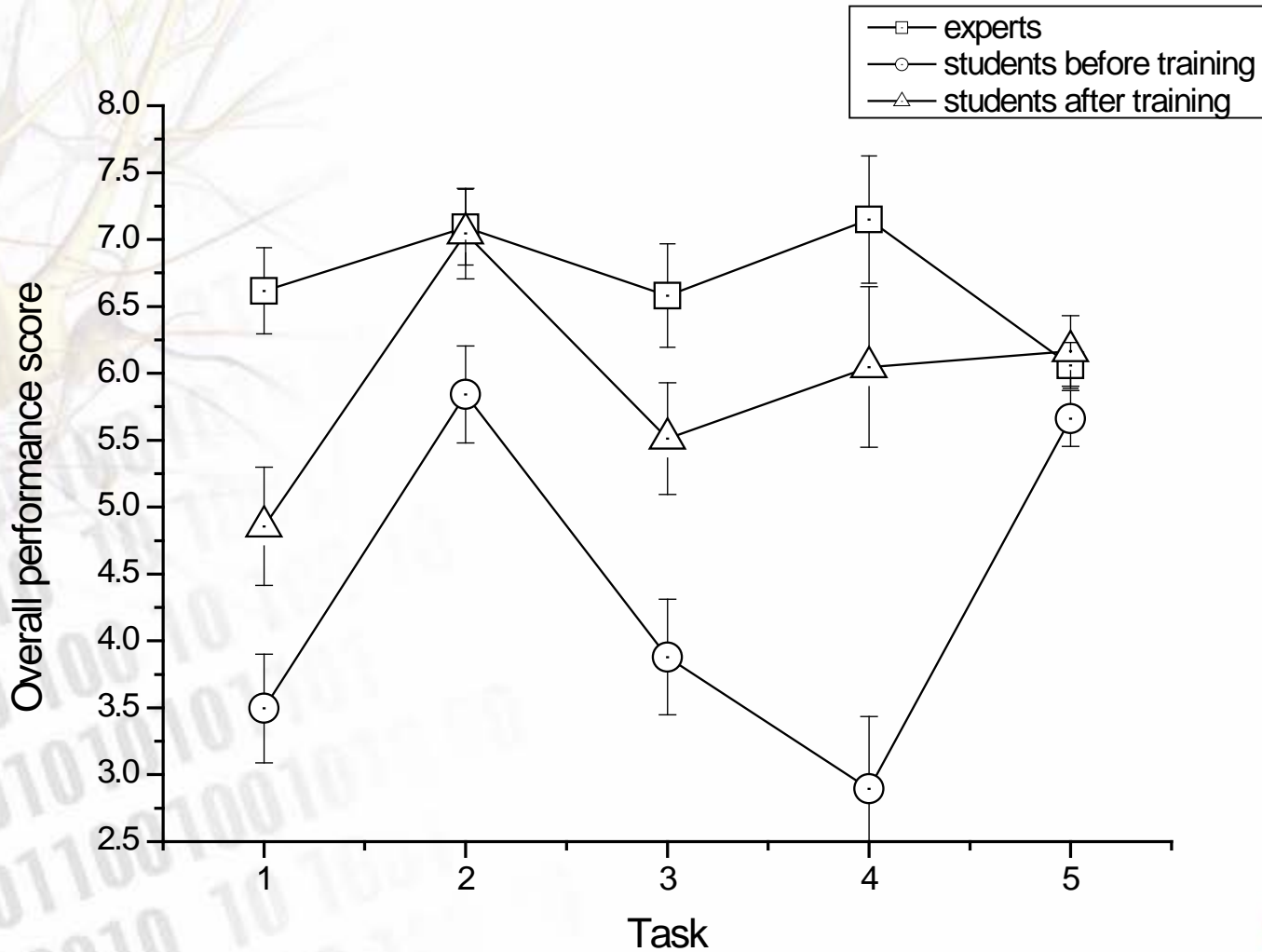
NSPh I – characterized by sharp increase, then decrease of HR over a short period of time.

NSPh II – characterized by HR increase connected with transient increase of arousal level.

NSPh III – characterized by HR decrease connected with transient reduction of arousal level.

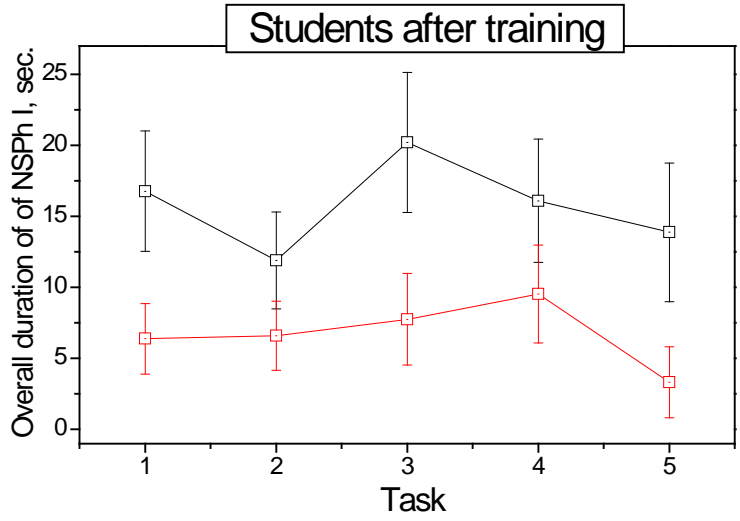
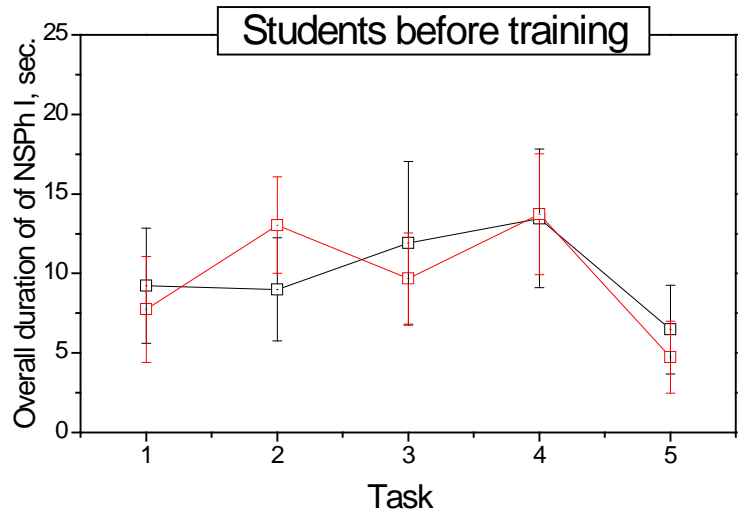
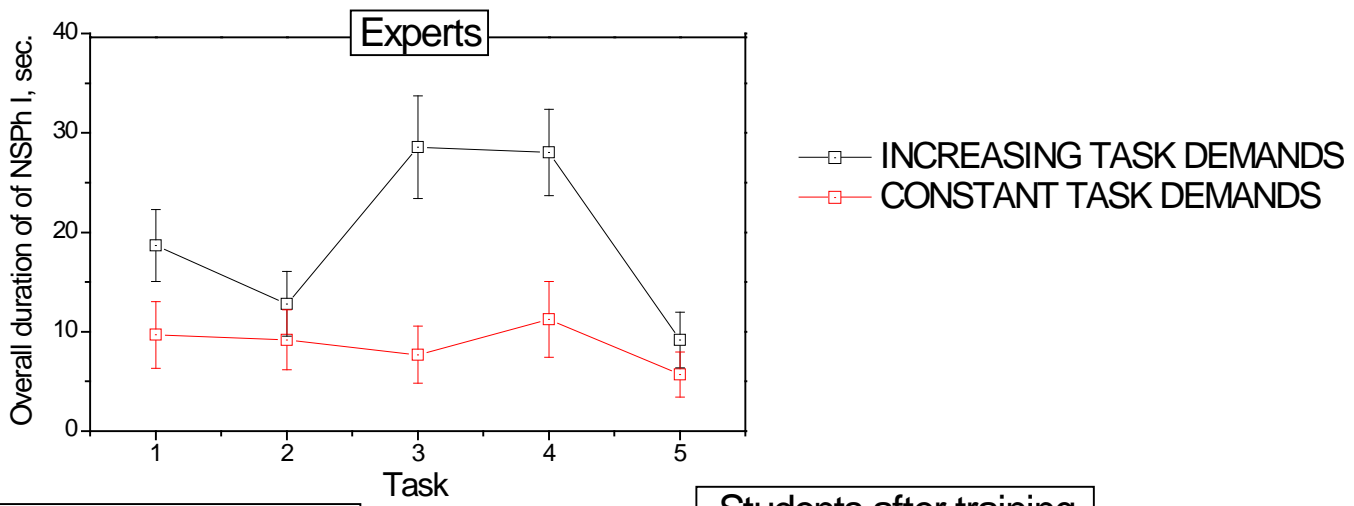


With training, performance scores of students approached that of experts





With training , the duration of Non-stationary Phases (NSPh) of students approximated experts



- **As students gain proficiency, there is**
 - increased physiological response to increased demands
 - a lessened response during constant demands
- **With task proficiency, there comes a capacity for optimizing the expenditure of physiological resources in response to changing task demands**
- **Data not presented here, showed that NSPh III duration increased with repeated failures and was attributed to reduced motivation**
- **These findings illustrate the potential of HR measures as a simple, readily fieldable metric of skill acquisition**

