Interpretable Multimodal Temporal Patterns of Trainee Behavior During Patient State Transitions in VR Simulation

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1. APPENDIX

This appendix provides supplementary materials that support the analyses presented in the main paper. Specifically, it documents the scenario-stage labels used in the VR cardiac-arrest simulation, including their encoded clinical rhythms, algorithmic branches, and associated training foci, as well as the formal definitions of clinical team roles and their corresponding data labels. We additionally include the original action and speech event codes extracted from the simulation logs to ensure transparency and reproducibility of the multimodal event modeling. Finally, we provide representative THEME T-pattern visualizations for expert and novice teams to show stage-wise temporal patterns and group-level coordination differences. These materials are intended to offer additional implementation detail and contextual grounding for readers interested in replication, secondary analysis, or methodological extension.

Table 1: Scenario stage labels (scripted phases) in the VR cardiac-arrest resuscitation case. Each label encodes the patient rhythm/state and the corresponding ACLS branch (shockable vs. non-shockable) or a post-ROSC care focus.

Stage label	Code (phase/branch/step)	Branch	Typical training focus / expected actions
V-Tach 2D	Phase 2 / Branch D	Shockable (VT)	Alternate shockable pathway; rapid rhythm recognition; coordinate CPR–shock cycle; enforce safety ("clear"); minimize hands-off time; re-assign tasks as needed.
V-Tach 2A.1	Phase 2 / Branch A / Step 1	Shockable (VT)	Canonical early shockable pathway; prompt defibrillation/cardioversion (depending on pulse) followed by immediate high-quality CPR; closed-loop communication and timekeeping.
V-Tach 2B.1	Phase 2 / Branch B / Step 1	Shockable (VT)	Alternative pathway (often reflecting delayed/suboptimal coordination); recover to guideline-consistent CPR–shock workflow; clarify roles and next-step planning.
Asystole 1D No.1	Phase 1 / Branch D / Occurrence 1	Non-shockable	Immediate CPR; administer epinephrine per protocol; avoid defibrillation; consider reversible causes (H's & T's); keep pauses brief during rhythm/pulse checks.
V-Fib 4C.1 – AMIO	Phase 4 / Branch C / Step 1	Shockable (VF)	Refractory shockable rhythm with medication cue; repeated defibrillation + high-quality CPR; administer amiodarone; coordinate drug timing with rhythm/pulse checks.
ROSC 5B – STEMI	Phase 5 / Branch B	Post-ROSC	Post-arrest stabilization; obtain/interpret 12-lead ECG (STEMI cue); manage oxygenation/hemodynamics; escalate care (e.g., cath lab activation) and prepare handoff.

Table 2: Clinical roles in the VR cardiac-arrest resuscitation simulation and how they were marked for training/data collection.

Role	Primary responsibilities in the scenario	Coordination/communication focus (examples)	Data mark (role label)
Team leader	Overall coordination; assigns tasks; maintains situational awareness; integrates updates from all roles; makes time-critical clinical decisions (e.g., rhythm checks, medication timing).	Directs workflow and priorities (e.g., "start CPR," "prepare shock," "give epi"); requests status updates; confirms closed-loop communication; transitions team across scenario stages.	*teamlead*
CPR provider	Performs high-quality chest compressions; pauses for rhythm/pulse checks when directed; coordinates compressor switches to maintain quality.	Verbalizes CPR status (start/stop, fatigue, switch needed); acknowledges leader commands; coordinates timing around shock and pulse checks.	*cpr*
Defibrillator operator	Operates defibrillator; attaches pads; analyzes rhythm; charges and delivers shocks when indicated; ensures safety during shock delivery.	Announces rhythm interpretation and readiness ("charging," "clear"); confirms shock delivery; coordinates with CPR to minimize hands-off time.	*defib*
Airway manager	Manages airway and ventilation (BVM/advanced airway as applicable); monitors breathing/oxygenation; coordinates ventilation with compressions.	Reports ventilation/airway status; requests/acknowledges tasks (oxygen, airway adjuncts); coordinates timing of breaths and confirms adequacy of ventilation.	*airway*

Table 3: Original action and speech event codes extracted from the VR simulation logs and used in this study. Event labels are preserved exactly as recorded in the dataset.

Modality	Original Event Code	Semantic Name	Description
Action	`administered_epinephrine`	Epinephrine administration	Administering epinephrine medication to the patient.
Action	`ascultate_lungs`	Lung auscultation	Auscultating lung sounds to assess airway and ventilation status.
Action	`cpr`	Chest compressions (CPR)	Performing chest compressions during resuscitation.
Action	`perform_bag_mask_pump`	Bag-mask ventilation	Providing manual ventilation using a bag-mask device.
Action	`pulse_check`	Pulse check	Checking the patient's pulse to assess cardiac activity.
Speech	`c_dta`	Task allocation	Assigning specific tasks or actions to team members.
Speech	`c_gta`	Role assignment	Assigning or confirming team roles and responsibilities.
Speech	`clc_dcb`	Directive check-back	Closed-loop confirmation of a directive or instruction (receiver confirms receipt/completion).
Speech	`clc_gcb`	General check-back	Closed-loop confirmation of general information or status updates.
Speech	`jip_ei_q`	Information elicitation (questioning)	Requesting information from teammates (e.g., vitals, timing, observations).
Speech	`jip_esi`	Information evaluation	Interpreting, assessing, or critiquing information shared by teammates.
Speech	`jip_si`	Information sharing	Providing factual or synthesized information relevant to the situation.
Speech	`m_sh`	Hypothesis statement	Stating a diagnostic or explanatory hypothesis about the patient's condition.
Speech	`sle_scu`	Expressing uncertainty	Expressing doubt, concern, or uncertainty about the diagnosis or next steps.

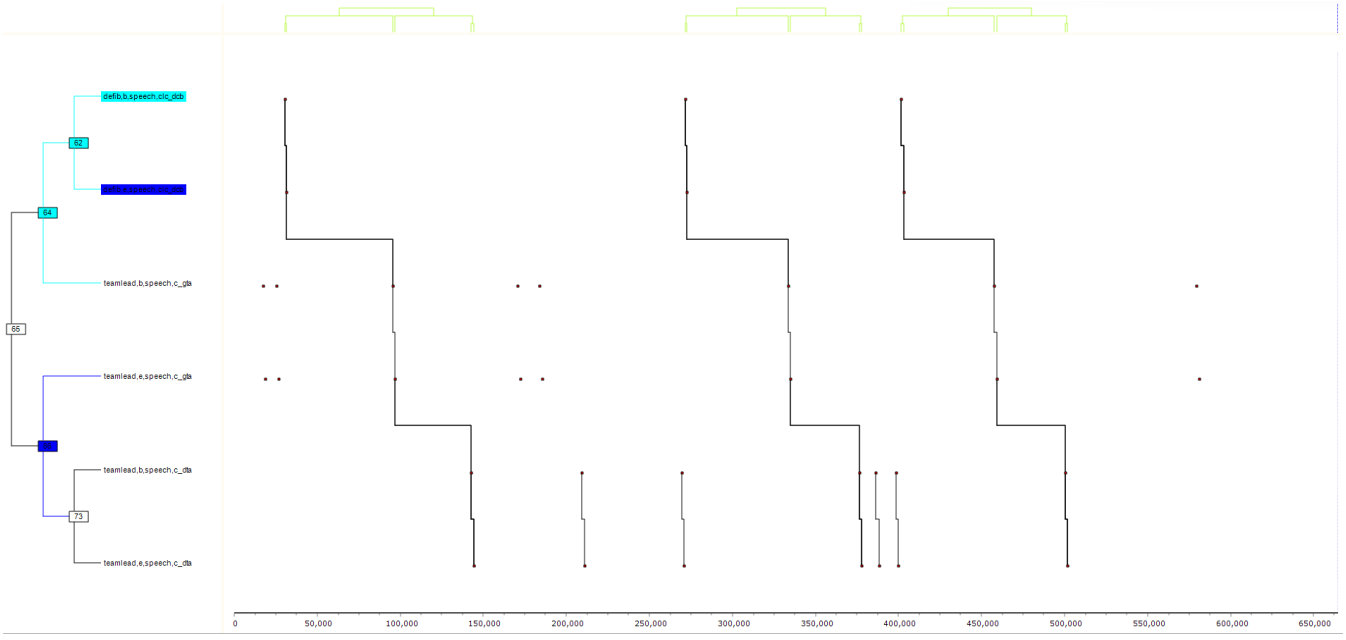

Figure 1: Novice 1

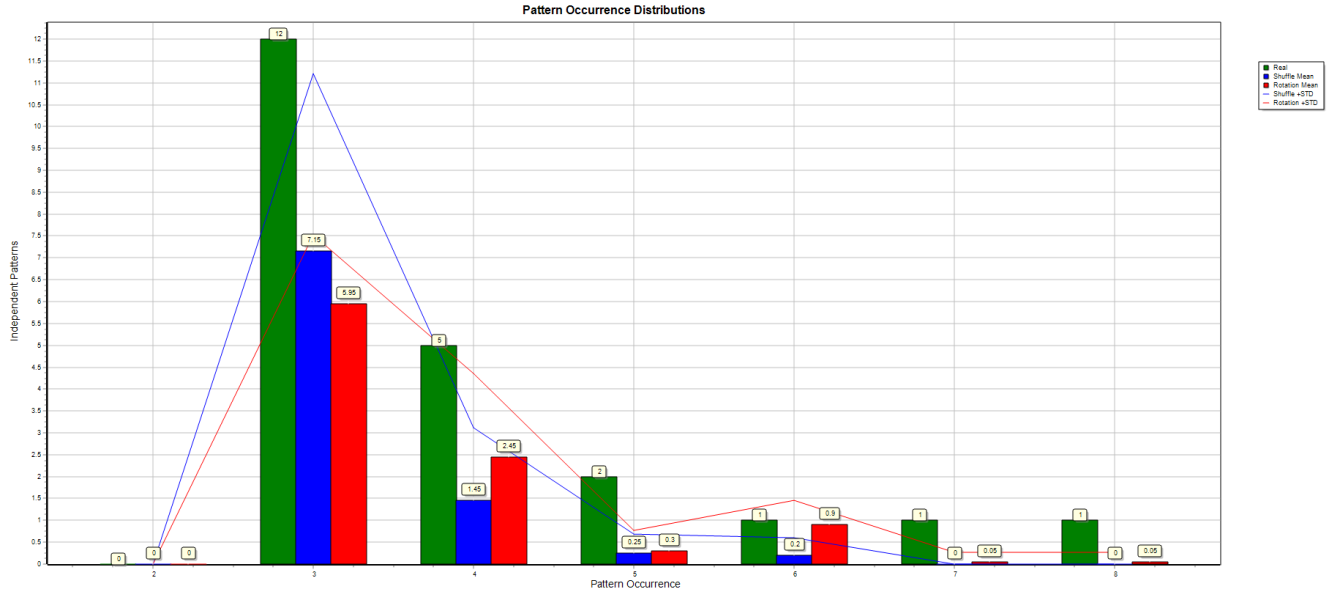

Figure 2: Novice 1

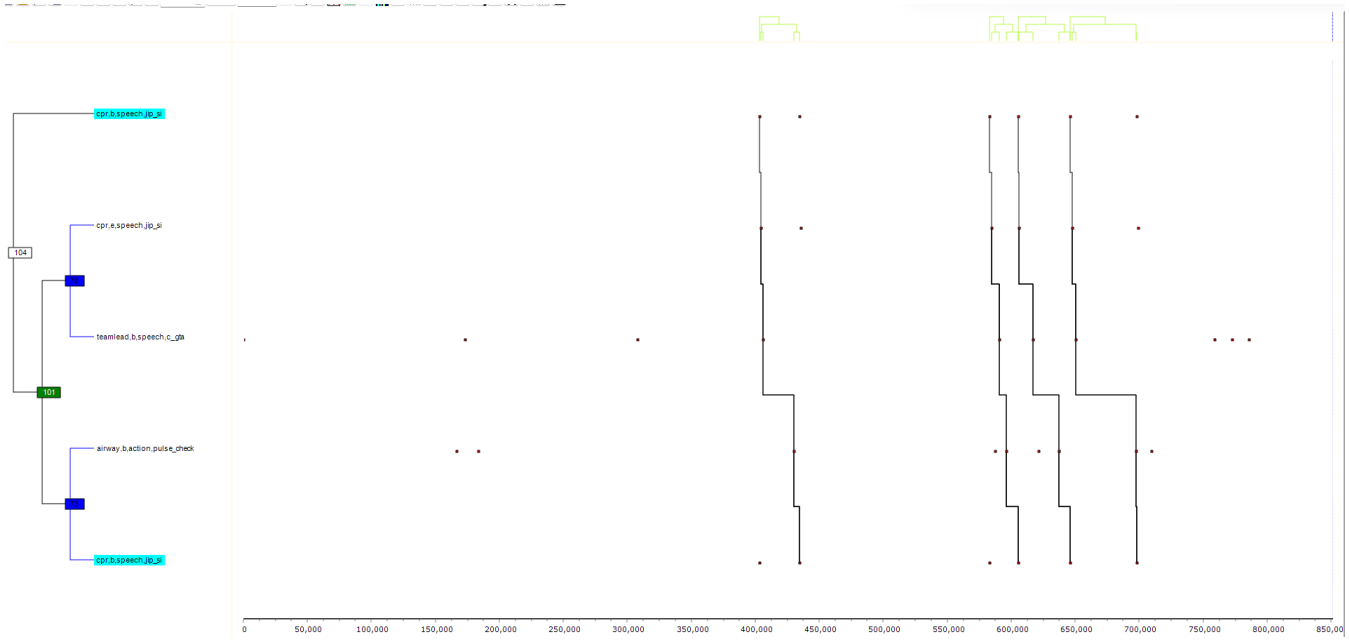

Figure 3: Novice 2

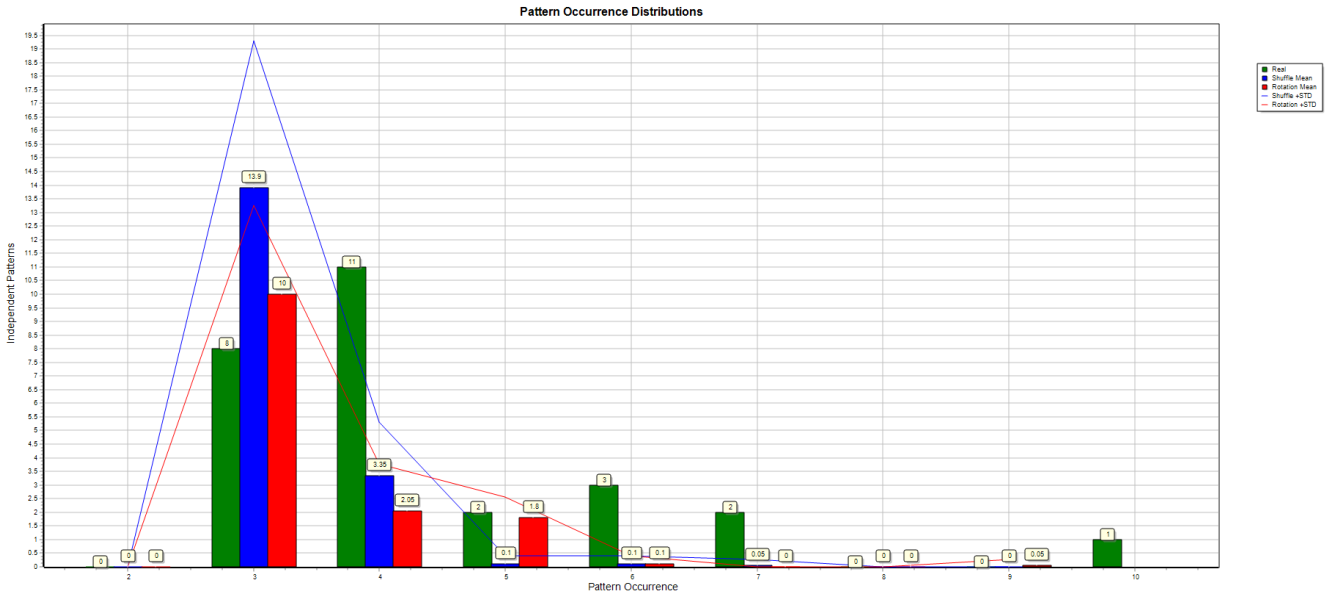

Figure 4: Novice 2

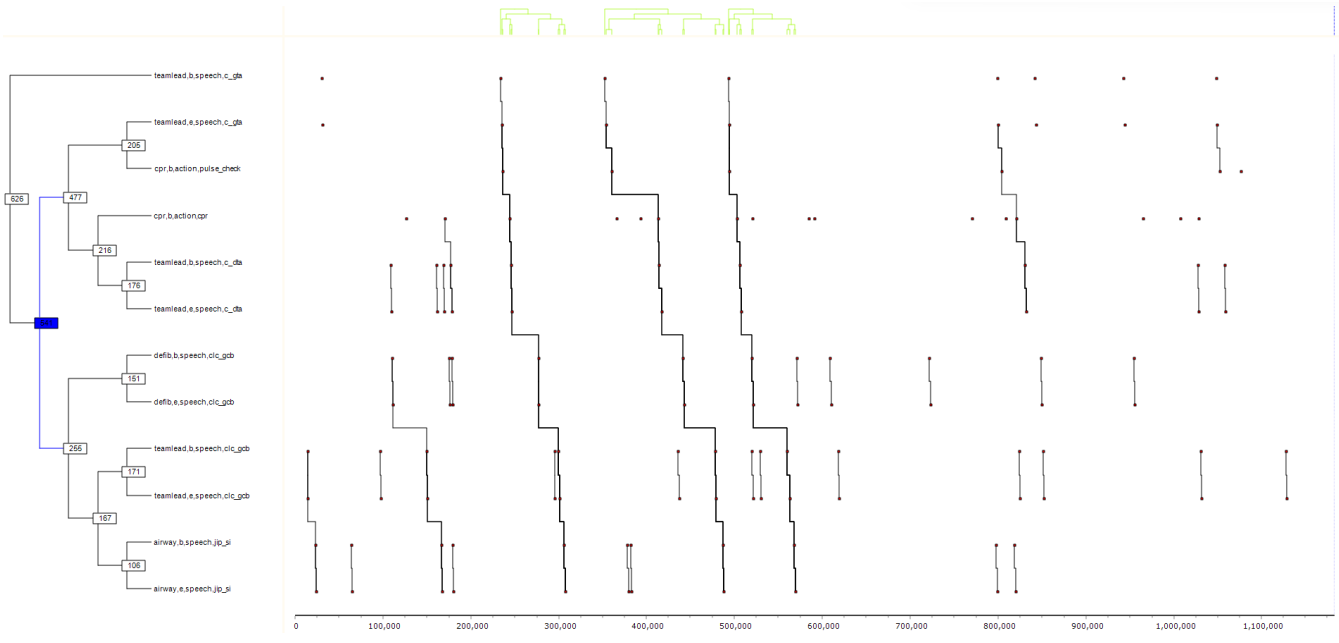

Figure 5: Novice 3

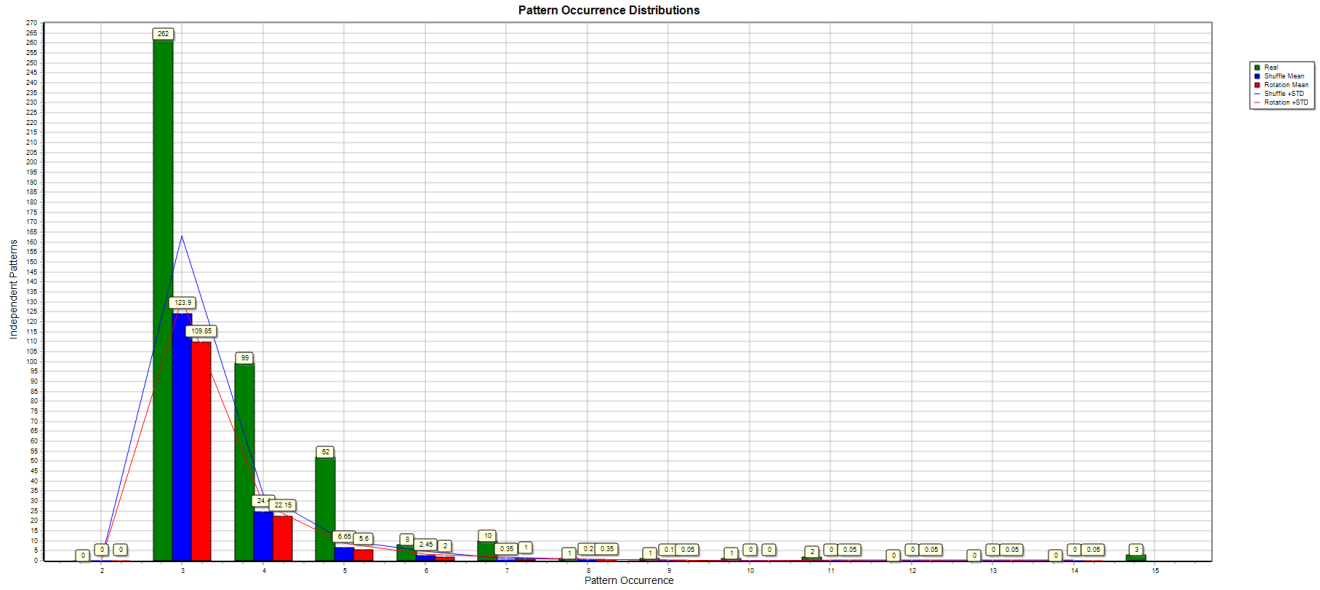

Figure 6: Novice 3

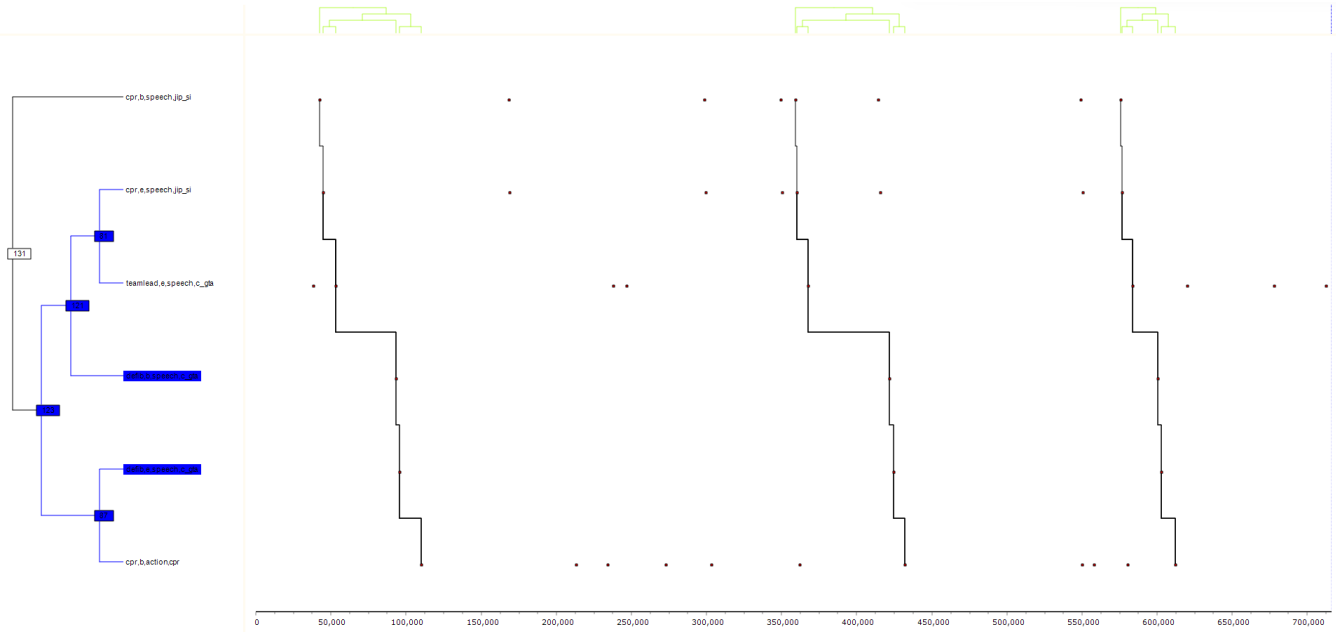

Figure 7: Expert 1

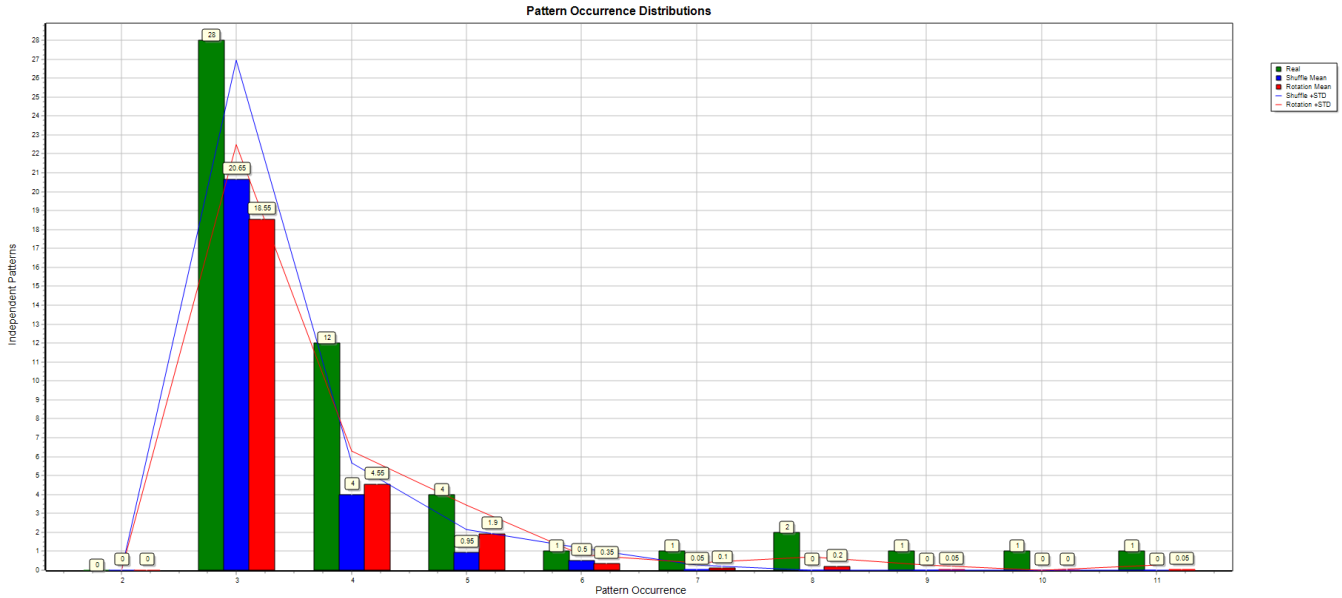

Figure 8: Expert 1

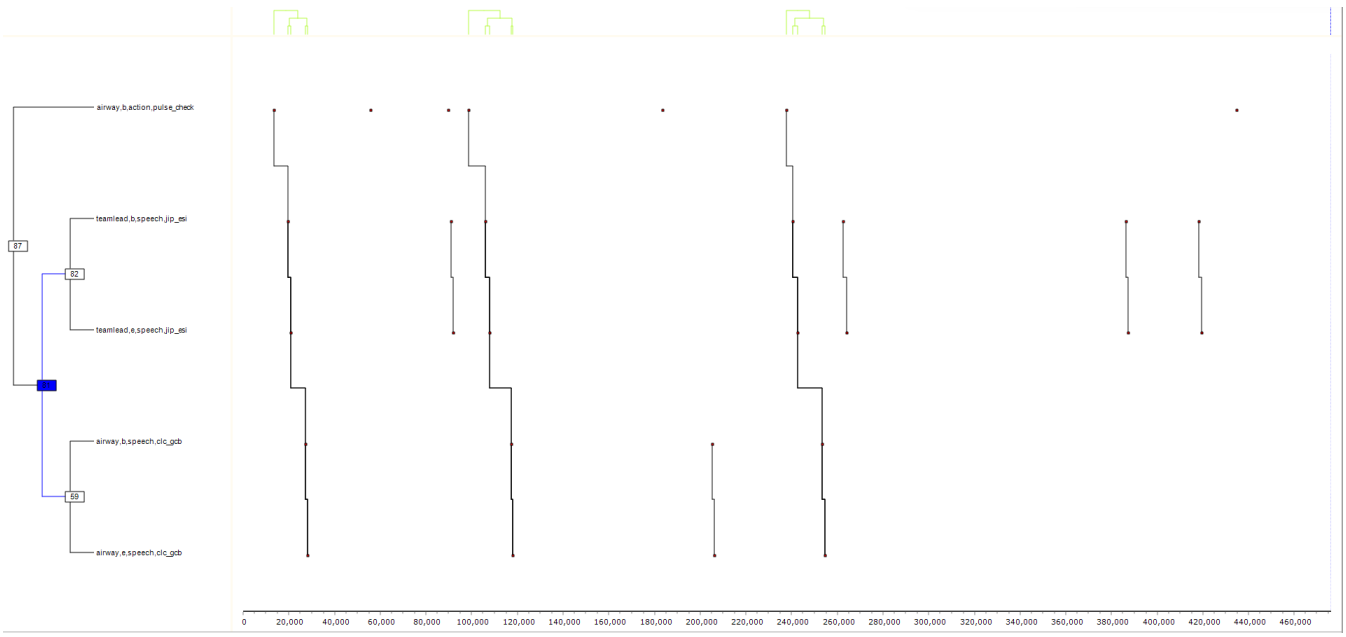

Figure 9: Expert 2

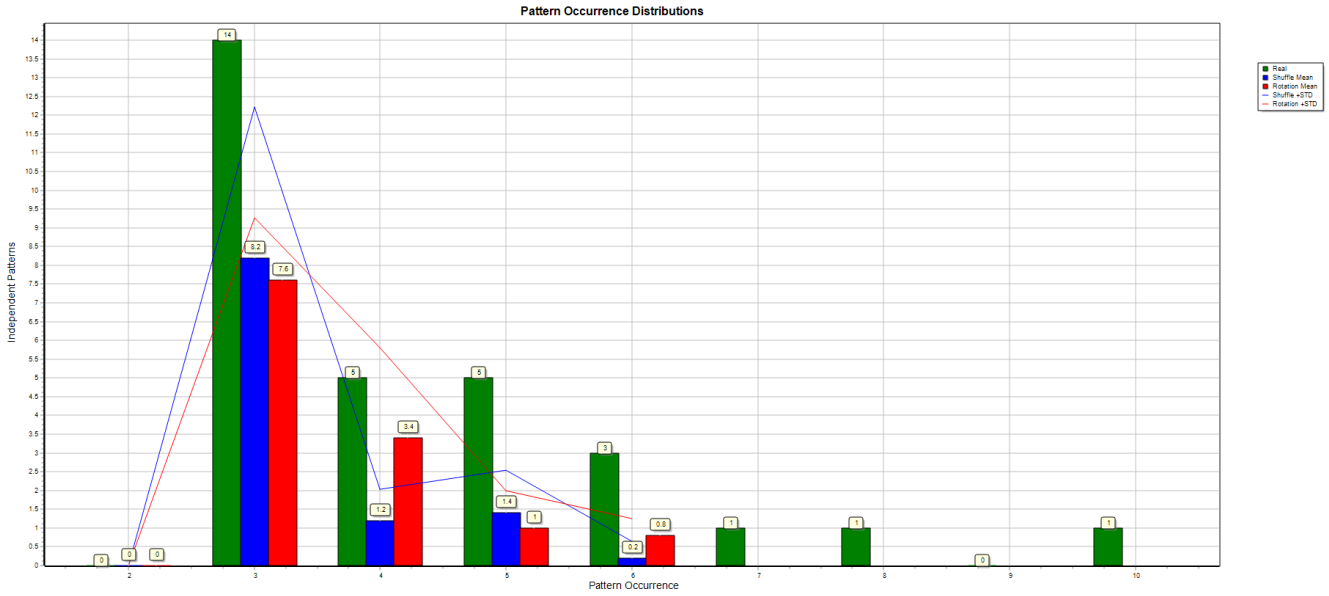

Figure 10: Expert 2

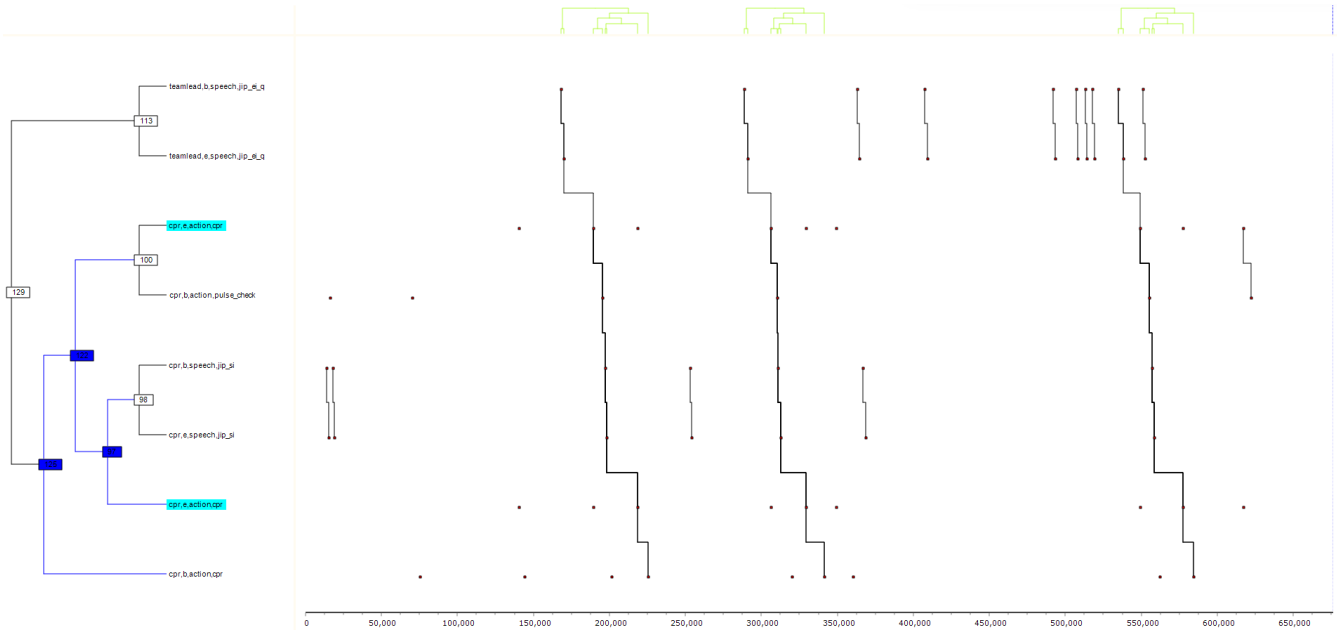

Figure 11: Expert 3

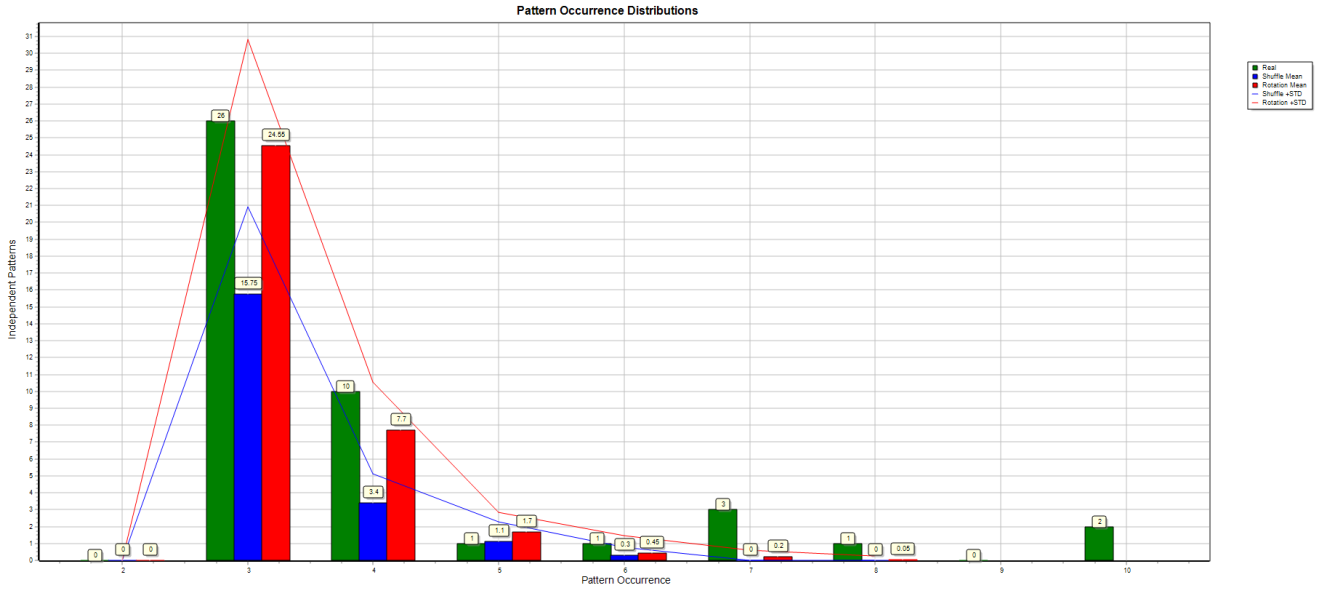

Figure 12: Expert 3