Exploring the Structure of Speed in Cognitive Diagnostic Models

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By incorporating collateral information such as response time (RT), cognitive diagnostic models have the potential to provide a more fine-grained picture of the examinee's latent skill profile. But this naturally creates two questions: (1) whether the mastery of a skill is always coupled with a faster speed compared to the non-mastery state? (2) What patterns of speed are shown in different skill profiles? To answer question one, we analyzed the PISA Math 2012 computer-based dataset via the most widely used deterministic input, noisy 'and' gate model and lognormal model to obtain examinees' pure latent skill profile and speed, respectively. Results revealed that: (1) the examinees who mastered the attribute tended to hold a slower speed than those who did not; (2) for each attribute, the mastered and non-mastered examinees displayed exactly opposite speed patterns. Specifically, the higher the speed of non-mastered examinees, the lower the speed of the examinees who master the skill, and the large differences between these two types of speed were observed in both easy skills with high mastery rates and hard skills with low mastery rates. For question two, we implemented a two-step clustering analysis to reveal natural groupings for speed and latent skills profiles. A 4-cluster solution was found, indicating that the high-ability-level examinees mastering most of the attributes had the slowest but most stable speed while the low-ability-level examinees had the fastest but most fluctuated speed. This study provides food for designing new cognitive diagnostic models incorporating RT.