ROLE OF EARLY FLYING PERFORMANCE IN PILOT TRAINING TRACKS

Rana Ihara, Yumi Shibata
Aeromedical Laboratory, Japan Air-Self Defense Force
Tokyo, Japan
Yuko Aiba
Acquisition, Technology & Logistics Agency, Ministry of Defense
Tokyo, Japan
Takenori Nomiyama, Asao Kobayashi
Aeromedical Laboratory, Japan Air-Self Defense Force
Tokyo, Japan

Early flying skills have been reported to strongly influence future flying skills. Few published studies have evaluated the comprehensive relationship among all flying training skills. This study evaluated three causal path models for flying skills that influenced flying performance rated by instructor pilots in five training phases. A covariance structure analysis showed that a sequential model with a connection between the first and last phases was optimum for representing flying training performance and skills. The flying skill acquired in the first training phase in a primary propeller aircraft influenced the last training skill in a fighter jet directly as well as indirectly. Furthermore, the influence of the first training phase on the fighter training skill was the strongest among all the training phases. These results suggest that the skill of flying a primary propeller aircraft is important in predicting fighter pilot skill and estimating the validity of pilot aptitude tests.

Long-term stability of individual diffferences in skill acquisition has been concerned during multi-year long training. There has been much research for both applied and basic situations (Ackerman, 1988; Hofmann et al., 1992, 1993; Alessandri et al., 2015). In the research, task configuration, for example, of task complexity or consistency, was key for determining individual differences over practice. When a complex task was repeated, individual differences remained constant or increased. However, when a task was consistently repeated, they decreased.

Tasks during pilot training could be defined as complex. In the Japan Air-Self Defense Forse (JASDF), pilot training consists of five progressive phases that are conducted using both propeller and jet aircraft: the first training phase is conducted using a primary propeller aircraft, T-7; the second to fourth training phases are conducted using a jet trainer, T-4; and the fifth training phase conducted using a fighter jet, F-15 or F-2. In the Japan Civil Aviation College, there are three flight training phases conducted utilizing both single-engine and dual-engine propeller aircraft. Pilot candidates are initially trained for basic flight skills in low-speed, simple aircraft. Later, advanced skills are acquired using high-speed, high-performance aircraft.

To acquire both skills, candidates are likely to practice multiple maneuvers for more than two or three years and join multiple training phases. It could be possible that tasks performed during pilot training are different among training phases rather than repetition of complex tasks.

Therefore, student pilots might need new abilities for subsequent training and individual difference in early training would not influence future training.

Several studies have shown the relationship of flying performance between various pilot training phases. Ree et al. (1995) demonstrated that the flying performance in a subsonic primary aircraft strongly influenced the subsequent flying performance in a supersonic advanced aircraft in the U.S. Air Force. The finding was true for both male and female pilots (Carretta and Ree, 1997). Okaue et al. (1973) suggested that the relationships between the four training phases in a previous version of JASDF pilot training were strong. Furthermore, the research indicated that the initial performance in a primary aircraft correlated with later performance in an advanced aircraft.

Prior research has suggested that early flying performance should predict subsequent flying performance. In other words, it was possible that individual differences remained over flying practice. Therefore, it was considered that tasks performed during pilot training would be complex and not change. However, there is no finding about comprehensive relationships among all flying training phases. Can we say that tasks performed during all flying trainings are complex and do not change?

Three Hypotheses of Flying Training Performance

Three hypotheses were proposed regarding the role of primary pilot performance in a sequential flying training environment in JASDF. To deal with the many flight training performance factors, such as landing, navigation, and formation, all hypotheses considered that the flying skill acquired in each training phase influenced flying performance.

First, we hypothesized that a flying skill acquired in a previous training phase would directly influence a flying skill in a subsequent phase only. Therefore, the first training skill would immediately affect only the second training skill. This straight model was based on the findings of Ree et al. (1995), which suggested that skills learned in flying a primary aircraft were required in flying an advanced aircraft. We expected that the influence of early skill was not so strong in later skills because it only indirectly influenced them. This hypothesis was called "Straight Model I (Figure 1a)."

The second model extended the Straight Model I, with the first training skill directly influencing the third training skill. The first and third training phases include mastering navigation. Navigation is considered to be a key maneuver because it is difficult to master it (Yang et al., 2013; Sullivan et al., 2011). Therefore, we hypothesized that the first training skill would strongly influence the third training skill. This model was called "Skip Model P (Figure 1b)."

The third model also extended the Straight Model I, with the first training skill directly influencing the fifth training skill, like a circle. This model, called the "Circle Model O," was proposed considering that student pilots are exposed to different aircraft types. They are introduced to and trained in new aircraft types in the first, second, and fifth training phases. In these three phases, students might be required to master an unfamiliar aircraft. Therefore, we hypothesized that the first training skill would directly influence not only the second training but also the fifth training skill. Our expectation was that a skill acquired early strongly influenced the last skill because the early skill influenced the last skill directly as well as indirectly (Figure 1c).

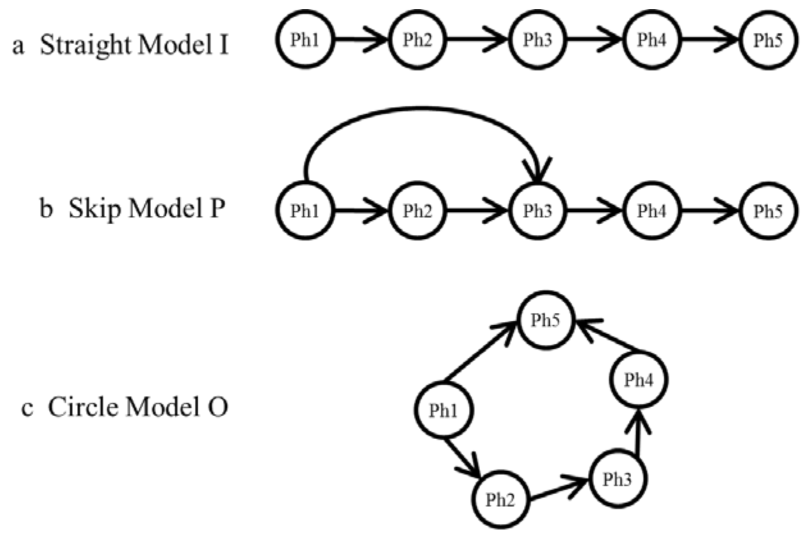

Figure 1. Hypothesized models.

Note. Ph1 through ph5 are the flying skill factors for the first through fifth pilot training phases.

Method

Participants

The participants were 270 JASDF male student pilots, who completed five pilot training phases. The age of the participants ranged between 20 and 29 years when the first phase began. These participants were either from the National Defense Academy, an accredited college or university, or the JASDF Aviation Cadet Corps. The participants who graduated from the National Defense Academy or an accredited college or university completed the JASDF Officer Candidate School before entering the pilot training course.

Flying Performance and Flying Skills

Student pilots were graded on maneuvers in each training phase. The maneuvers were different according to each phase; the first training phase, in a primary propeller trainer (T-7), included takeoff, landing, and basic navigation; the second training phase, in a jet trainer (T-4), included takeoff, landing, and formation; the third training phase, using the same aircraft as the second phase, included navigation for commercial pilot license; the fourth training phase again in the T-4, included elementary tactical maneuvers; the fifth training phase, in a fighter jet (F-15 or F-2), included takeoff, landing, and tactical maneuvers. We considered the flying skill of a student pilot in each phase as a factor affecting affecting their execution of these maneuvers, which was considered to be equivalent to flying performance in this study.

Data Analysis

A covariance structure analysis was performed on maneuver scores using PASW Statistics 18 and Amos 18 statistical analysis software. According to Toyoda (1998), an adequate fit is indicated if the value of root mean square error of approximation (RMSEA) is less than 0.05. With regard to the comparative fit index (CFI), values closer to 1.0 indicate better models. Akaike's information criterion was used for model comparisons, and the lowest scoring model was recommended.

Results

Goodness-of-fit indices of models are shown in Table. The RMSEA values of all the models were found to be acceptable. Circle Model O appeared to have the best fit among the competition models (CFI = 0.933; AIC = 658.364). The standardized estimates of the effects between flying skill factors among Circle Model O's variables are shown in Figure 2. The influence from the first training skill to the last training skill was directly 0.31 and indirectly 0.28 (0.81 × 0.79 × 0.90 × 0.49).

Table.
Fit indices of models of flying performance structure in pilot training phases.

Model	RMSEA	CFI	AIC	Description
Straight Model I	0.046	0.928	668.262	Model with indirect effects.
Skip Model P	0.045	0.930	666.513	Straight Model I with direct effect of a flying skill factor from ph1 to ph3.
Circle Model O	0.044	0.933	658.364	Straight Model I with direct effect of a flying skill factor from ph1 to ph5.

Note . RMSEA = root mean square error of approximation; CFI = comparative fit index; AIC = Akaike's information criterion. Ph1, ph3, and ph5 are the first, third, and fifth pilot training phases, respectively.

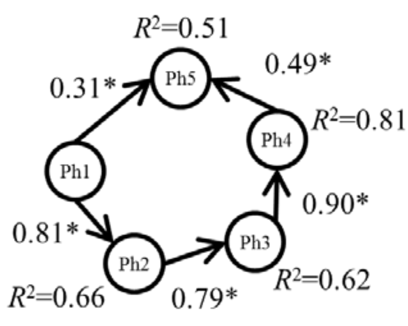

Figure 2. Path coefficients of Circle Model O.
$*P < 0.01$.

Note. Ph1 through ph5 are the flying skill factors for the first through fifth pilot training phases.

Discussion

The results showed that previous training skills influenced subsequent training skills. Moreover, the first training skill was confirmed to influence the last training skill both directly and indirectly. This was because student pilots may need similar skills in order to master an unfamiliar aircraft in both the first and fifth phases.

The effects of each phase on the fifth training skill were calculated: first phase 0.59 (0.31 + 0.28), second phase 0.35 (0.79 × 0.90 × 0.49), third phase 0.44 (0.90 × 0.49), and fourth phase .49. Among all the training phases, the first training phase had the most substantial effect on the fifth training phase. The first training performance was an important predictor of the last training performance.

The first training phase was strongly connected to the last phase. This means that the tasks during pilot training might involve complex repetitions and individual differences are retained throughout practice. From another point of view, however, the coefficient of determination (R^2) of the last training skill, as shown in Figure 2, was 0.51 and variances that we could not explain remained. It may be possible that the remaining variances were caused by new abilities in new tasks. We must continue to study the possible causes of these remaining variances.

In longitudinal studies on achievement tests, it was reported that relationships existed between the test scores near grades (Bloom,1964; Bracht & Hopkins,1972). In addition, the scores between far grades correlated (e.g., between third and eleventh grades, r = 0.82). First-year scores had direct and indirect effects on fourth-year scores in medical college (Harada & Nakamoto, 1997). These findings indicate that individual differences in early performance were maintained and the findings of the pilot training were consistent with those obtained by previous studies.

The findings of this study have a great impact on the development of pilot aptitude tests. The primary aim of these tests is to select persons who have the potential to become good pilots. When we evaluate pilot aptitude tests, in the truth, we want to use the flight duty performance scores of the pilot candidates who took the tests. Waiting a few years—which is usually the time required for a pilot candidate to become a duty pilot—to estimate the validity of pilot aptitude tests is undesirable. Therefore, it is helpful if the first training performance can predict the last training performance, and can be used as a criterion variable for evaluating future performance.

Interpreting the results from another perspective, enabling student pilots to further improve at each training phase might help them attain improved performance in all subsequent training phases. In particular, when the first training performance improves, the last training performance can also improve despite the use of different aircraft. The training values can be helpful in training student pilots now and in the future.

The findings of this study can be helpful in evaluating pilot aptitude tests and determining training values. However, these findings may lead to students having a fixed mindset, which might affect training performance. Blackwell et al. (2007) suggested that the students with a growth mindset were able to raise their scores, whereas the students with a fixed mindset werenot. Ratten et al. (2012) showed that instructors with a fixed mindset were likely to comfort low-performing students, and students respond to such comfort-oriented feedback with lower expectations of their own performance. In particular, in training or educational situations, exaggeration of the effect of early training might have a negative influence.

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