

The Influence of Pilot Age and Expertise on Comprehension and Decision-Making Tasks

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INTRODUCTION

Experts excel on domain-relevant tasks in part because their knowledge allows rapid retrieval from LTM, which can help bypass working memory limits (Ericsson & Kintsch, 1995). Domain-specific knowledge may preferentially aid older experts, by mitigating age-related cognitive declines (Morrow et al, in press). We investigated whether expertise mitigates age declines on pilot comprehension and decision-making tasks because decision-making is central to piloting and is heavily dependent on knowledge and experience (Orasanu & Fischer, 1997). Expert (airline) and novice (General Aviation, GA) pilots read scenarios that varied in familiarity to airline pilots, and then performed several tasks that measured comprehension and decision-making accuracy.

PREDICTIONS

1. Expert pilots (airline vs GA) will be more accurate than novice pilots for both scenario comprehension and decision-making skills.
2. Cognitive declines are more likely to limit older novices, who cannot depend on situation-relevant schemata to support decision-making. This expertise mitigation may be more likely for more familiar situations, which require less effortful knowledge-based processing for pilots.

METHOD

PARTICIPANTS

Seventy-four pilots participated. **Table 1** shows that older pilots (46-60 yrs) experienced typical declines in working memory and cognitive speed compared to younger pilots (20-42 yrs) but performed better on the vocabulary test. Experts and novices did not differ on these domain-general tests, and both groups experienced age-related declines. **Table 2** shows that expert pilots had more flight experience than the novice pilots, and outperformed them on a declarative measure of expertise.

Table 1: Demographic and Cognitive Ability Scores
F-test $df = (1, 70)$ * $p < .05$ ** $p < .01$

	YE (n=20)	OE (n=19)	YN (n=25)	ON (n=10)	F age	F expertise	F A*E
age	32.6	54.9	26	54.5	339.21**	6.39*	50.3*
education	15.9	16.6	15.6	16.5	ns	ns	ns
WM ¹	4.6	4.1	4.3	3.8	5.59*	ns	ns
speed ²	30.6	28.2	31	26.3	14.99**	ns	ns
vocab ³	16.9	22.2	14.6	21.6	33.3**	ns	ns

1. Measure of working memory (WM) is mean of listening and reading versions of the sentence span task (Stine & Hindman, 1994).
2. Processing speed is indicated by the mean of Letter and Pattern Comparison tasks (Salthouse & Babcock, 1991).
3. Advanced Vocabulary Test from the Kit of Factor-Referenced Cognitive tests (Ekstrom, French & Harmon, 1976).

PROCEDURE

Participants read 6 scenarios describing a problem that developed during flight. Scenarios varied in complexity and familiarity, with participants receiving 3 complex (and less familiar) and 3 simple versions. (See **Figure 1** for an example). Simple and complex versions were identical except for the final sentence, which usually complicated the pilot's response to the problem. Thus pilots should need more domain knowledge in order to understand and respond to the more complex scenarios. After reading through each scenario twice, participants rated the complexity and familiarity of the problem and answered several comprehension questions about the scenario. After reading all scenarios, they completed a multiple-choice questionnaire about the best course of action for each situation.

Figure 1

DEPARTURE AIRPORT: Kansas City Downtown
DESTINATION AIRPORT: Chicago O'Hare
CURRENT POSITION: Kansas City Downtown Airport
AIRCRAFT ALTITUDE: N/A
TIME OF DAY: 4 PM CST
GROUND TEMPERATURE: 71 degrees F
WIND CONDITIONS: N 3 kts
DEPARTURE AIRPORT CONDS: Below landing limits
DEPARTURE RUNWAY: 01: 7001' long, West
ALTERNATE: (takeoff) Kansas City INTL, 16 mi N
AIRCRAFT: Medium-size, wing-mounted, twin-engine jet with leading edge devices
You are taxiing along the east ramp southbound to runway 01. It is minimal visibility throughout the airport and other ground traffic is showing their frustrations with the delays. Your aircraft has arrived at the end of the runway and you are cleared for takeoff as you make your right turn to line up on the active runway. You are now on the takeoff roll and at V1, when out of the fog ahead appears a tug towing an engine crane across the runway. You yank back on early liftoff, ...
(Simple version)
but the left underside of the airplane still strikes the crane. You remain airborne and climbing and there are no instrument indications of a problem. Both hydraulic pressures are normal and a green light indicates normal leading edge devices.
(Complex version)
but the left engine still strikes the crane and separates from the airplane. You remain airborne and climbing but with asymmetrical lift, and yawing. Both hydraulic pressures have gone to zero and a yellow light indicates leading edge device asymmetry.

Table 2: Flight experience & Domain knowledge

F-test $df = (1, 70)$ * $p < .05$ ** $p < .01$

	YE	OE	YN	ON	F age	F expertise	F A*E
knowledge	15.5	14.3	14.5	12.9	6.16*	4.50*	ns
recent hrs ¹	619.9	606.5	171.8	60.4	ns	112.84**	ns
instr hrs	1666.9	4231.9	80.5	123.8	ns	12.88**	ns
total hrs ²	6247.3	14399.5	457.3	728.1	29.55**	157.76**	25.87**

1. Recent hours are those flown within the last 12 months.
2. Despite a significant interaction in total hours, the main effects here are of greater interest. We expect older pilots to be more experienced than younger pilots, and airline pilots to have more total hours than those who fly General Aviation aircraft as a hobby. The differences between both expertise groups and both age groups show vast differences which should not compromise our findings.

RESULTS

SCENARIO COMPREHENSION

Figure 2 shows that experts understood the scenarios more accurately than novices ($F(1, 70) = 5.098, p < .05$). Younger pilots also were more accurate than older pilots ($F(1, 70) = 8.403, p < .01$). However, there was no interaction between age and expertise on this measure. Also, simple scenarios were understood more accurately than complex scenarios ($F(1, 70) = 5.285, p < .05$).

DECISION-MAKING

Figure 3 shows that experts exhibited more accurate decision-making skills than novices ($F(1, 70) = 7.07, p = .01$). Here, however, the benefit of expertise is reduced for the complex vs the simple scenarios ($F(1, 70) = 6.4, p < .05$).

Figure 2: Scenario Comprehension

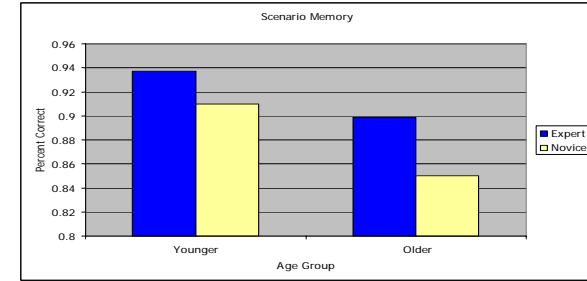
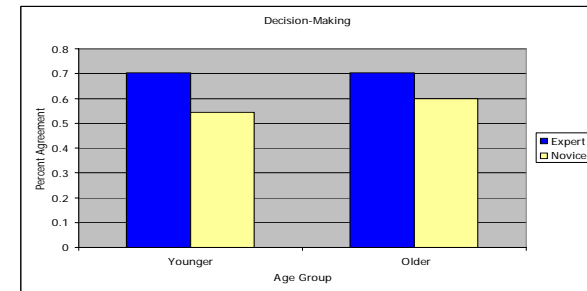


Figure 3: Decision-Making



DISCUSSION

1. Experts understood the scenarios more accurately than novices. Expertise and scenario complexity did not, however, mitigate age-related differences. Note that relatively few older novices have participated. When this group is complete, we will be in a better position to test age X expertise interactions. We also plan to analyze scenario reading time in order to further investigate knowledge/age tradeoffs in comprehension strategies.
2. Experts also made more accurate decisions about responding to the problems in the scenarios. Scenario complexity appeared to reduce expertise benefits for decision-making accuracy. The divergence of scores in the decision-making measure among experts may indicate varied approaches possible in troubleshooting more complex problems. We are now coding talk-aloud decision-making protocols, which should provide more information about the effects of age, expertise, and scenario complexity on decision-making processes. Finally, a more comprehensive investigation of the benefits of experience for older pilots' decision-making will involve analysis of older and younger pilots' responses to problems in a flight simulation environment.

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