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Advancements in technology has made obtaining a graphical/textual preflight weather briefing easier than a traditional verbal briefing. This study compared weather briefings delivered in a verbal format (i.e., written narrative) to those delivered in a graphical format (i,e., radar map plus textual data) in a within-subjects study that altered the order in which participants received each format. Thirty-six pilot participants read and responded to weather briefings for two flight scenarios that when put together, created a simulated multi-leg flight. Each pilot's decision making and confidence in their decision was captured via Likert-scale and open-ended questions following each scenario. Decision making response was measured based on whether participants made a "go" or "no-go" decision, along with ratings of decision confidence. This paper will present the study methods and results, as well as a discussion on weather briefing design and delivery.

According to Fultz & Ashley (2016), adverse metrological conditions have contributed to 35% of general aviation (GA) accidents with 60% of these accidents occurring in instrument metrological conditions (IMC). Analyzing current and forecasted weather conditions along the intended flight path, prior to takeoff, is crucial to the safety of any flight. Due to advancing technology in the GA industry, pilots are now able to access weather information in various formats that can aide or hinder their decision-making abilities. The goal of the weather briefing prior to takeoff is to increase a pilot's situational awareness of all of the weather-related hazards along the intended flight route. Situational awareness is defined as the perception of critical elements in the environment, comprehension or their meaning, and the projection of their status into the future (Wickens, Hollands, Parasuraman, & Banbury, 2012). Situational awareness is critical within the aviation environment because many responsibilities that fall on a pilot are time-critical and occur within a dynamic environment. A study by Topçu (2017) also supported that individuals must monitor a dynamic environment as this could alter their goals and desired outcomes, therefore affecting decision-making. Despite the number of weather-related GA accidents that have occurred, Fultz and Ashley (2016) suggest that relatively little is known about the overall characteristics of these types of accidents. This research gap in weather-related accidents prompted this study into pilot decision-making and confidence under dynamic environmental conditions.

This study focused on evaluating the impact of preflight weather briefing format on pilot decision making. Two formats that are currently available to pilots were selected for analysis: a verbal weather briefing and a graphical/textual weather briefing. A verbal weather briefing is typically obtained when a pilot makes a phone call to a professional weather briefer. Weather information is shared verbally over the course of this phone call, and the pilot is able to take notes during the briefer's narrative. A graphical/textual briefing is typically obtained through the use of a computer or tablet. Pilots are able to view weather charts and diagrams as well as textual data presented in a Meteorological Aerodrome Report (METAR) format. A METAR is a compilation of the observed weather elements at an individual ground station, such as an airport (FAA, 2016). These two formats were analyzed for their effects on a pilot's decision-making ability and decision confidence.

Methods

This study utilized a survey method which presented pilots with a paper-based scenario and associated weather briefings. Each scenario was comprised of two legs, one to Sebring, FL and one to Okeechobee, Fl, each with their own hazardous weather. The study incorporated a within-subjects independent variable (IV) of weather briefing format, so each participant received both a verbal and a graphical/textual weather briefing. There were two between-subjects IV's in this study: the order of the two flight legs and the order in which each briefing format was received. Both flight order and format order were counterbalanced, creating four orders in which the scenarios could be presented to the participant.

Participants

Participants were selected through convenience and snowball sampling strategies, with all participants being certified Private Pilots or higher. The study sample was comprised of flight students and flight instructors from a flight school in central Florida. Flight students and flight instructors were recruited via email, direct messaging or word of mouth. Once a participant was selected for the study, they were assigned a number in chronological order from 1-36. One of the four surveys, labeled A, B, C, and D respectively, were assigned to each participant. The order of the distribution of these surveys was randomized via a dice roll. The number "3" was the result of the first dice roll, and this corresponded with survey C being paired with Participant 1. The survey order was then paired in alphabetical order with each subsequent participant.

Questionnaire Procedure

The survey was shared with each participant in a digital format though a Google Form. Results were then exported from the Google Form responses into an Excel spreadsheet for data analysis. Participants began each survey by providing demographic data, which included total flight hours, simulated and actual instrument hours, and level of certification. Next, participants proceeded to the scenario portion of the survey. Each survey was split into two halves, with each half representing one portion of the multi-leg flight. The verbal weather briefing information was presented as a written narrative taken from a briefing obtained over a phone call to an official weather briefer. The graphical/textual weather briefing information was presented as images of a radar depiction chart and a line of METAR code. Both scenarios were followed by Likert-scale questions to capture likelihood to make a "go" or "no-go" decision and the confidence each pilot had in this decision. The anchors for decision making ranged from

"Extremely Unlikely" to "Extremely Likely" and anchors for confidence ranged from "Not Very Confident" to "Very Confident." After the Likert-scale questions, several open-ended questions were posed to each participant to answer the "why" behind a pilot's indicated level of likelihood to fly and the confidence in their decision.

Results

Participant Demographics

Thirty-six pilots participated in this study, including seven Private Pilots, twelve Instrument-Rated pilots, eight Commercial Pilots, four Certified Flight Instructors, three Certified Flight Instructors – Instrument, and two Airline Transport Pilots. Of the 36 pilots, 32 were male and four were female. Pilot age was collected, with a mean across participants of 21.2 years (*SD* = 2.07). Pilots also reported their total flight hours and total instrument hours (simulated and actual). For total flight hours, the mean was calculated as 399.0 hours (*SD* = 491.5 hours). For total instrument hours, the mean was calculated as 71.1 hours (*SD* = 32.0 hours).

Effect of Weather Briefing Format and Scenario Order

To account for order effects, the order in which the scenarios were presented and the order in which the formats were presented were coded into two between-subjects variables (scenario order: Okeechobee first, Sebring first; format order: graphical first, verbal first). A repeated measures MANOVA was run with one within-subjects independent variable, weather briefing format, and two between-subjects independent variables, the order of the weather and the order of the two scenarios." The two dependent variables in the study were decision (based on likelihood to "go" of "no-go") and confidence in the decision. No main effect for the format of the weather briefing on either of the dependent variables was found; however, the interaction between the format of the weather briefing and the order of the scenario presented for decision approached significance ($F(1, 32) = 3.956$, $p = .055$, partial $\eta 2 = .110$). When Sebring was presented first, the pilot was more likely to "go" for the verbal format than the graphical format. When Okeechobee was presented first, the pilot was more likely to "go" for the graphical scenario than the verbal. The results are illustrated in Figure 1, which represents the group based on scenario and format order, where A = SV, B = SG, C = OV, D = OG, with S = Sebring Airport, O = Okeechobee Airport, V = Verbal Format, and G = Graphical/Textual Format).

Effect of Weather Briefing Format and Scenario Order

There was also a statistically significant interaction between the format of the weather briefing, the order that the formats were received, and the order that the scenarios were received for decision ($F(1, 32) = 4.833$, $p = .035$, partial $\eta 2 = .131$), and for confidence ($F(1, 32) = 6.201$, $p = .018$, partial $\eta 2 = .162$). Pilots were more likely to "go" in trial one than they were in trial two, regardless of which scenario or briefing format was presented first. The only exception to this was when the Okeechobee scenario l was presented first with a verbal weather briefing. Pilots were more confident when presented with either Okeechobee scenarios first, with confidence reducing in the later Sebring scenarios. Pilots who received Sebring in graphical format first gained confidence after they received Okeechobee in verbal format second. In trial one, pilots were most confident when they received Okeechobee in verbal format and least confident when receiving Sebring in graphical format. In trial two, pilots were most confident when receiving Okeechobee in graphical format and least confident when receiving Sebring in verbal format (see Figure 1 below).

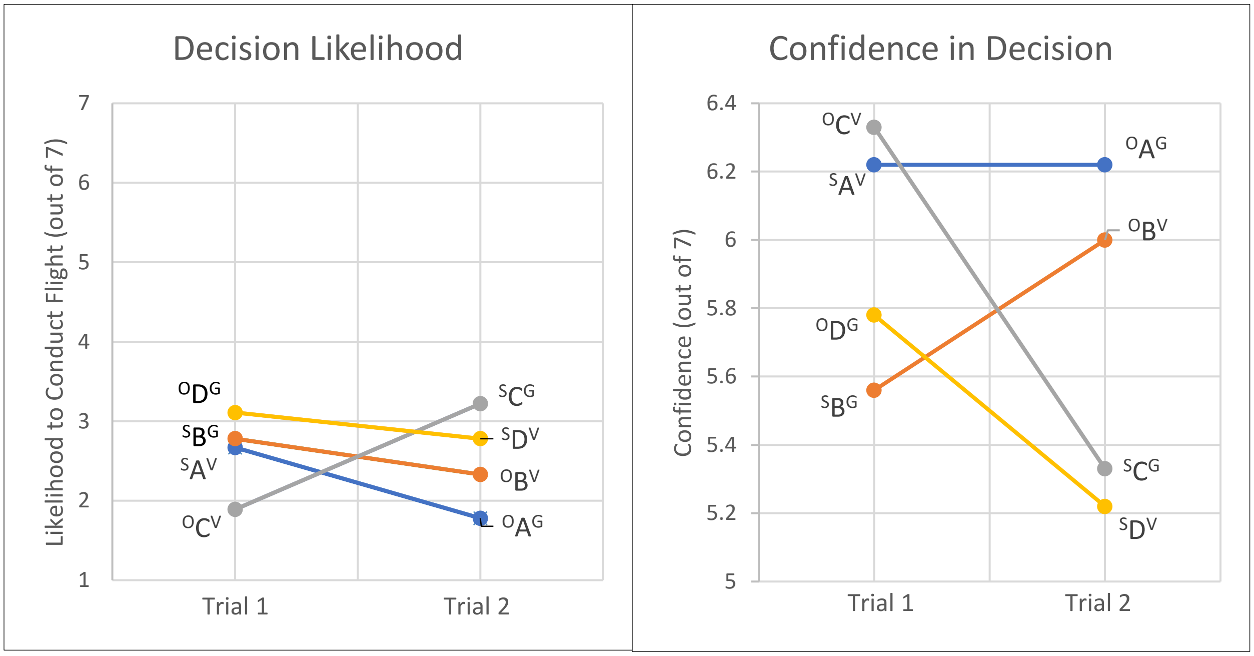

Figure 1. Decision Likelihood and Confidence Between Trials 1 and 2

Discussion

Overall for the decision to “go” or “no-go,” participants in trial one were more likely to “go” when they received a graphical briefing first. However, these same pilots were less confident in this decision. This might have been because pilots could visually see where hazardous weather (in this case precipitation) is located in relation to their origin and destination. However, these pilots were not confident in this decision which may be due to pilots having to weave in and out of hazardous weather while enroute; a behavior that does not promote a safe flight. Pilots who received the verbal briefing first were less likely to fly but were more confident in this decision. This may be due to pilots not being able to see precipitation or low cloud ceilings when the format was verbal. Because pilots were provided information only in a verbal briefing, they were confident in terminating the flight due to the lack of multiple sources of information, specifically missing visual information. For the second trial for decision and confidence, pilots who received the Sebring graphical scenario were the most likely to fly but were not confident in their decision. The Sebring flight contained very low cloud ceilings, low visibility, but no precipitation. In the graphical/textual briefing, the text stated that there were low ceilings, but this could not be depicted in the visual aid, which only showed precipitation. For this scenario, no precipitation was present. The textual data listed that fog was present at Sebring while the visual aid did not show any hazard near this airport. The pilots who received this scenario were likely to fly but were not confident in their decision. This may have been due to the graphical/textual data not supporting one another and being unable to portray a common threat between them. The difference between the textual and graphical data was intended as the precipitation radar pictured on each survey is able to show the location and intensity of rain, but not fog. The information between the textual and graphical sources did not directly contradict one another, but it instead required the pilots to more carefully analyze the radar image after reading the line of raw textual weather data. Pilots could have fully understood the hazards that both the precipitation and low clouds posed if the graphical/textual data showed the same information. Likewise, the Okeechobee graphical scenario, when presented second, made pilots the least likely to fly but the most confident in this decision. This may be due to the precipitation being considered a greater threat when presented after the low ceilings from the Sebring scenario. This result shows an order effect when the pilots were presented with the scenario involving low cloud ceilings. Although these low ceilings were first considered hazardous, the pilots were even less likely to "go" but more confident in this decision during the second trial perhaps due to the precipitation being considered a comparatively greater threat.

The most interesting interaction for decision was the difference between trials one and two when the Okeechobee verbal scenario was presented first. This was the only group of pilots whose likelihood to make a "go" decision sharply rose while their confidence in this decision sharply fell when they received the Sebring graphical scenario second. This may have been due to the fact that the precipitation was only being depicted verbally, preventing pilots from visually seeing the location and intensity of the precipitation. This resulted in pilots that were unlikely to fly and were confident in that decision. Upon receiving the graphical/textual Sebring scenario, the pilots saw a visual aid that displayed very low cloud ceilings and no precipitation. The weather diagram showed no precipitation over Sebring, as also depicted in the line of textual weather data. In the textual weather data, Sebring was reporting very low ceilings. Because the weather diagram was not able to depict cloud ceilings, there was no conflict between the textual weather and the diagram either. The pilots were likely satisfied with receiving a more cohesive briefing that did not clearly present hazardous weather and this resulted in the higher likelihood to fly but less confidence due to the high chance of low cloud ceilings.

Conclusion

This study focused on how verbal and graphical/textual weather briefings affected a pilot's decision-making and confidence during preflight. Overall, it appears that graphical/textual weather briefings will result in a pilot being more likely to conduct a flight under deteriorating weather conditions. This is potentially due to the images of the current weather conditions clearly showing the location and intensity of poor weather. Pilots may be less confident when deciding to "go" on a flight after receiving a graphical/textual briefing because even though they deem the flight safe, they area aware that they may be required to navigate around potentially hazardous weather while enroute. Pilots utilizing a verbal briefing may be less likely to conduct a flight due to the lack of a visual aid accompanying the narrative of hazardous weather. Pilots may be more confident in this "no-go" decision because the termination of their flight means that they will not have to worry about dodging hazardous conditions while enroute.

This study has a direct impact on the safety of GA flights and how pilots obtain and analyze preflight weather briefings. This study mimicked a multi-leg flight, each with slightly different hazardous weather conditions. Results suggest that the type of briefing received for each leg should by tailored to the type of weather condition: graphical/textual briefings should be used for precipitation and verbal briefings should be used for areas of low visibility. Reversing the type of briefing might result in a more likely "no-go" decision due to the lack of information in the briefing that would fail to support the weather phenomena. The practical significance of this study for GA flights is that pilots need to be aware of the limitations of each type of briefing. Since pilots do not have control over the type of weather they might encounter, they need to ensure they are utilizing the correct briefing format during preflight. Ideally, a pilot could use both types of briefings, thus eliminating the limitations of each format. However, this is largely dependent on the equipment available to the pilot during preflight.

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