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Using Conversation Analysis in Data-Driven Aviation Training with Large-Scale Qualitative Datasets

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Data collection that is quantitative or coded at the point of origin is conducive to large-scale data analysis. Parametric data of flight and engine parameters are inherently quantitative examples (Stolzer, Halford, & Goglia, 2008) and ASAP/ASRS reports are examples of coded data (Beaubien & Baker, 2003). Large-scale quantitative data has arguably contributed to safe and efficient operations in many domains, including aviation as an input to Flight Operations Quality Assurance (FOQA) programs, Safety Management Systems (SMS), and Advanced Qualifications Programs (AQPs) (Esser, 2006; Federal Aviation Administration [FAA], 2006a, 2016a; Stolzer, Wu, & Halford, 2006). The growth of digital audio and video technologies offers a significant new data source for FOQA, SMS, and AQP programs, provided the data can be effectively managed, protected, and leveraged. Parametric, audio, and video data have already proven invaluable to mishap investigations (National Transportation Safety Board [NTSB], 2015, 2016a).¹

In order to leverage audio and video data, the present study adopts a qualitative, constructivist epistemic stance, whereby meaning is socially constructed, moment-by-moment, by individuals interacting together. This stance seeks to inductively find meaning in interactional environments through observations of participant actions (Creswell, 2003). Conversation Analysis (CA) provides a valuable qualitative methodology for *informing* many professional workplace operations by collecting, transcribing, and coding naturalistic audio and video recordings (Arminen, 2005). Recent work in CA has extended the *informing* practices of CA to *interventionist* applications to improve workplace interactions (Antaki, 2011). As

¹ This study is an independent effort of the researchers and is not endorsed or associated with the National Transportation Safety Board, the federal government, or the governments or aviation and safety regulators of the countries of collaborating researchers. All audio/video content herein was voluntarily submitted for the purpose of this study.

discussed in this paper, Stokoe's (2014b) Conversation Analytic Role-play Method (CARM) is the appropriate interventionist framework used and evaluated in this study.

The present, ongoing study collects voluntarily submitted audio and video recordings of primary flight instruction training flights. The purpose of the study is to show how the CARM framework—tailored to large-scale, long-duration interactions—may be applied to the recordings to create interactive training targeting two goals: (a) flight instructor effectiveness and (b) student radio communications. This study of a new training method is significant in light of the FAA's recent creation of the Air Transportation Center of Excellence for Technical Training and Human Performance in 2016, which

will examine human factors issues such as changes in learner expectations and academic best practices for training a new generation of learners. The center also will research innovative training methods for this new generation. This includes new technologies such as mobile learning as well as new ways of collecting and managing training data. (FAA, 2016b, para. 5)

This paper identifies and reviews literature to present the basis for the study, describes the methodology developed by the present study, offers early and formative results thus far, and points to future directions. Results include a grounded-theory node structure that makes the recorded data accessible for further analyses, insights into instructor effectiveness, radio communication exemplars, and two exemplar training interventions using the CARM framework. Future work will synthesize the exemplars into systematic patterns of interaction (Stokoe & Sikveland, in press).

Literature Grounding the Study

There are currently no large-scale studies demonstrating the effective use of audio and video recordings to intervene in the flight training environment. Accordingly, this literature review draws upon other environments where audio and video have been applied effectively and then relates these to flight training. This relationship is explicated first by describing aviation training, then describing CA and how it has been used to describe aviation. Next, CA applications used to inform educational practices are described, transitioning to interventionist applications of CA in education and other domains. Through the review of these varied domains, a potential relationship between flight training and interventionist CA is established. Upon this relationship, the specific interventionist CA approach of CARM is introduced, suggesting that a gap exists in the literature between CARM and aviation applications, which this study intends to fill. Finally, qualitative coding of media is discussed followed by background information on aviation radio communications.

Aviation Training

Core to achieving safe and effective practice and operations, aviation requires multiple levels of training. Limiting the scope to pilots alone, there is basic primary training (private pilot) and advanced primary training (instrument and commercial). Other training includes pilots transitioning to different types of equipment, recurrent training, upgrade training, and line training (FAA, 2006a, 2008). Training includes technical and cognitive skills, such as risk management, decision-making, and crew resource management (CRM) (FAA, 2016a; Tuccio, Esser, Driscoll, McAndrew, & Smith, 2016).

Training for commercial operators includes the use of simulators and operational environments, including line operation simulations, line oriented flight training, and line

operational evaluations, to name a few. Collectively, these different training environments may be grouped under the concept of Advanced Qualifications Programs (AQPs), defined by the FAA as a data-driven process to develop systematically crewmember training programs (FAA, 2006a). The FAA encourages innovative methods and technology within AQPs (FAA, 2006a).

For the present study, an accessible population of basic and advanced primary flight instruction was considered. The primary training environment provides a primordial site for the study of training interactions using audio and video data. Flight instructors act as mentors and teachers to students who are learning new skills in a challenging and often less than ideal teaching environment (e.g., noise, vibration, workload) (FAA, 2008).

As teachers, flight instructors initially learn basic concepts of teaching, and then professionally develop through practice, formal learning, and networking (FAA, 2008). Every two years, flight instructors must renew their certification, which is often completed through a 16-hour flight instructor refresher clinic (FIRC) (FAA, 2015a).

Aviation instruction shares features with other educational environments. Through the micro-analysis of talk-in-interaction, CA has studied how teachers and students interact to create understandings between themselves and the object of their interaction: learning. For this reason, CA is explained before discussing how CA has been applied to education.

Conversation Analysis

Talk has been called the primordial means through which people create and express understandings of their activities, situations, surroundings, and roles. Especially when occurring in a technological environment, talk, technology, and interaction are interdependent and occur together as talk-in-interaction (Arminen, Auvinen, & Palukka, 2010).

Conversation analysis has been used extensively for analyzing the organization and outcomes of naturally occurring talk and social interaction, especially in contexts of professional work and learning. Studies use recordings of authentic situations to show in micro-detail how participants collaboratively produce and understand their interactions, whatever it is they are doing together (Nevile, 2006a). Originating in sociology, CA is usually traced back to a paper on turn-taking in conversations by Sacks, Schegloff, and Jefferson (1974). As Nevile (2006a) states, CA “examines precisely how communication is something people accomplish jointly and ‘locally’ (i.e. there and then). CA shows how reasoning and understanding for ordinary social action is necessarily situated in processes of interaction” (p. 38).

Since its inception in the 1970s, CA has been applied to various professional settings, including education, law and policing, business, medical, counseling, human-computer interaction, architecture, media, and sociotechnical settings (see Arminen, 2005). Examples of the diversity and settings of CA applications include Llewellyn and Hindmarsh (2010), who provide a comprehensive account of the practices and understandings by which organizations conduct and exhibit their defining characteristics, Heritage and Maynard (2006) who present studies of primary health care providers interacting with their patients, and Heath (2014) who examines art and antique sales transactions by auction. Most relevant here are CA studies of aviation settings, including Nevile’s (e.g. 2004a, 2006b, 2007) investigation of airline pilots’ routine collaboration, studies of interaction for air traffic control (ATC) coordination and training (Arminen, Koskela, & Palukka, 2014; Koskela, Arminen, & Palukka, 2013), and flight crew interactions focusing on distributed cognition (Hutchins & Klausen, 1996).

Naturally occurring data are the central focus of CA, for examining precisely how people do whatever it is they do in real-life situations. These data come from audio and/or video

recordings from natural environments as opposed to experimental or interview settings (Fitch & Sanders, 2005). Highly detailed transcriptions and accounts of recordings are made according to a prescribed system, originally developed by Gail Jefferson (see Jefferson, 2004) and bearing her name. Jeffersonian transcripts contain key features of participant turn-taking, overlapping talk, silence, hesitation tokens (e.g., “mm”, “hm”, “uh”), speed and volume of talk, stretching and abbreviating words, pitch variants, voice quality, breathing, crying, and laughter, because these features have all been shown to be highly significant for how participants themselves jointly create, understand, and organize interaction and activity.

Detailed transcripts are used to analyze how participants create and understand what they are doing, evidenced by what they say and do, and exactly how/when they do so. Accordingly, any analytic claims must be made relative to what is available in the transcribed data and therefore are grounded in participants’ own ongoing ‘analyses’ of what is happening.

Fundamental to CA is the sequential organization of talk and activity, providing evidence of participant understanding as it occurred, moment-to-moment, of how one contribution (utterance, action) somehow follows another (generally see Schegloff, 2007; for aviation see Nevile, 2013).

An example of an audio-oriented CA study of aviation is shown in Excerpt 1 from Nevile (2006a, p. 44). The first column contains line numbers, the second column abbreviations for speakers, and the last column the transcribed text. Lines 1, 5, 7, 12, and 14 show periods of silence between turns at talk, to tenth of seconds. Italicized lines 2 through 8 show communications over the radio. Markers “>...<” in line 2 show faster speech. Embedded parentheses of “(.)” show a micropause in speech; whereas, items such as “(1.4)” in line 3 indicate a 1.4 second pause in speech within a turn. Lines 8 and 9 use square brackets “[]” to show overlapping (simultaneous) talk. Line 9 shows how stretching of a word occurs, “o::kay::”.

Excerpt 1

Exemplar Jeffersonian Transcript of an Aviation Setting (Airline Cockpit, Actual Scheduled Passenger Flight)

- 1 (2.6)
 2 ATC: >bravo juliet tango< ah (.) two miles east centreline and closing,
 3 reduce to final approach speed er (1.4) cleared a visual approach
 4 caution: wake turbulence, (.) contact tower on final.
 5 (1.5)
 6 C/PNF: reduce to (.) final approach, tower on final, (.) bravo juliet tango.
 7 (0.9)
 8 ATC: >juliet juliet< mike (.) cli:mb to [: flight level two hundred]
 9 C/PNF: [o::kay::] speeds,
 10 FO/PF: ok[ay I might (0.3) decrease: ah: (0.7) to:: one hundred and eight,
 11 JJM: [two hundred juliet juliet mike
 12 (0.3)
 13 FO/PF: for the approach,
 14 (1.8)

Conversation analysts will expand on transcripts; for example, elaborating on Excerpt 1, it shows how the C/PNF (captain, pilot not flying) waits for it to be clear that ATC is talking to another aircraft (see lines 8-9) by hearing the full identification, before initiating the next relevant task, and the FO/PF (first officer, pilot flying) replies in line 10. Both pilots talk over the controller's turn, suggesting that it is not relevant to them.

Applications of conversation analysis in aviation. There have been a number of studies examining the use of CA in aviation. In *Beyond the Black Box: Talk-in-Interaction in the Airline Cockpit*, Nevile (2004a) recorded audio/video data from 18 scheduled flights and described the talk-in-interaction of airline cockpit crews. The work spawned follow-on analyses of flight deck discourse including describing approach briefings (Nevile, 2004b), sequencing new tasks (*and*-prefaced turns at talk) (Nevile, 2006b), coordinating talk and looking at flight

instruments (Nevile, 2010), and timeliness for contributions in flight-crew interaction (Nevile, 2007).

For example, Nevile (2007) observed the sparsity of overlapping (simultaneous) talk in the airline cockpit as evidence of precision timing on the flight deck,

Airline pilots precisely time their talk so as not to create overlapping talk, and this timing realizes an orientation to the temporal and strictly sequential nature of their work.

Precision timing creates a recognizably orderly flow of talk for work, whereby current talk is allowed to be completed before next talk is begun. (p. 244)

For the present study of flight instruction, observing how the practice of overlap may vary from that of the highly scripted airline environment may offer foundational areas of exploration.

Arminen, Auvinen, and Palukka (2010) used CA to study the behaviors of air traffic controllers and airline crews when repairing troubled talk-in-interaction. The authors sought to relate Reason's Model of Accident Causation to the practice of repair in interaction, and provided further detail to enhance understandings of the actual mechanisms of repair in aviation.

Particularly relevant here, Melander and Sahlström (2009) used CA to describe the development of situational awareness of a pilot undergoing instruction. The authors audio and video recorded three lessons of the same student working on the equivalent flight maneuver (recovery from unusual attitudes) and transcribed relevant parts. Embracing a constructivist paradigm, the authors used CA to examine moment-to-moment interaction and the creation of meaning for the participants. The authors observed learning exhibited by "micro-longitudinal changes in the student's understanding and performance of" the maneuvers under study (p. 164). Like other CA studies in this section, Melander and Sahlström (2009) sought only to describe the phenomena rather than offer prescriptions for improvement (intervention).

Applications of CA in Education

In this section, some CA educational studies are reviewed to identify and examine aspects of interaction which constitute or inform instruction and learning, as might be relevant for aviation. Examination of learning concludes with interventionist applications of CA to learning environments.

Learning computer interaction. Koschmann (2013) reviewed CA studies of collaborative learning, noting how CA offers a natural laboratory to study how understanding is produced in collaborative activity settings. In one study, two students were recorded learning the basic mechanics of using a computer program (see Roschelle, 1992). In the interactional sequence, micro-details of talk were exposed to reveal how understanding was progressively developed, including identification of the instructor's troubled understanding and subsequent repairs.

Classroom turn allocations. Summarizing Sacks et al. (1974) and Heritage (2005), Koschmann (2013) points out that turn allocation is managed in a traditional classroom by the classic practice of students raising their hand to be recognized. Using CA, an understanding of what constitutes the teacher's role in managing an educational setting may be recognized through detailed observation of the apparently simple practice of hand raising.

Other examples of talk in educational settings are “designedly-incomplete utterances” (Margutti, 2010, p. 316), which is a way of questioning formed by the teacher producing part of an utterance and the student completing the utterance. In this practice, the teacher speaks in such a way as to make clear a change of speakership is appropriate (teacher to student), known as a “transition-relevant place” (Koschmann, 2013, p.153). The teacher's utterance and the student's response are elements of a conversation organization known as “turn construction units”

(Koschmann, 2013, p. 153). Using these CA terms, the turn construction unit of the teacher is intentionally emphasized as noticeably incomplete by stretching final syllables and rising intonation, creating a transition-relevant place. Such utterances can then be completed by the recipient learner, as evidence of understanding (Margutti, 2010).

Lerner (1995) used CA to study second-language learning in a classroom to discover what opportunities exist for participating in instructional activities. Lerner's study used a corpus of video recordings of bilingual third-grade students engaged in story reading and related writing activities. Interactional sequences were used to describe the classic learning sequence of "elicitation-reply-evaluation" (p. 115), whereby the instructor asks a question, the student replies, and the instructor provides an evaluative response. Significantly, when the reply was correct, the evaluation tended to be shorter, and when the reply was incorrect, the sequence was extended (Lerner, 1995).

From study to intervention. In a CA study of second language learning, Sert (2013) goes beyond descriptions of interaction to propose using CA to improve instructor effectiveness, indicating potential for application to aviation training,

...to discuss the advantages of a [language teacher education] program that is informed by micro-analysis of teacher and student talk in language classrooms, which also enables novice teachers to reflect upon their own interactional and pedagogical practices. (p. 232)

Interventionist Applied Conversation Analysis

Sert's (2013) application of CA to improve interactional practices is known as interventionist applied CA (Antaki, 2011). Introducing a collection of such studies, Antaki (2011) presents five conditions for the success of interventionist applied CA: (1) an interactional problem pre-exists the analyst's arrival; (2) the problem recurs; (3) it is likely the problem is

related to the sequential organization of talk; (4) a solution is found by working collaboratively with members of the organization; and (5) there is agreement the discovered solutions will solve the problem.

Examples of interventionist CA applications include: victims of aphasia and their families (R. Wilkinson, 2011), people with intellectual disabilities and their caregivers (Finlay, Walton, & Antaki, 2011), new mothers and telephone counselors (Kitzinger, 2011), telephone surveyors eliciting information about ethnicity (S. Wilkinson, 2011), call takers related to conflict mediation services (Stokoe, 2011), and in aviation, dyadic pairs of pilots practicing CRM skills (Tuccio et al., 2016).

Tuccio et al. (2016) studied aviation students using a process of collaborative transcription and repair based learning (CTRBL) to foster CRM training in aviation. CTRBL captures interactional problems into an audio recording excerpt. Pilot-learners then engage in a two-step, collaborative process: (1) transcribe the audio; and then (2) repair problems discovered by marking up the transcript. The process fosters repetitive listening, negotiation, shared understanding, and agreement on what represents an ideal scenario. Tuccio's (2013) study demonstrated statistically significant positive student reactions to CTRBL when compared to traditional methods; additionally, post-intervention measures of learning were also statistically significant.

Conversation Analytic Role-play Method (CARM)

Considering interventionist CA methods, CARM as developed by Stokoe (2011, 2013, 2014b) has demonstrated success in a number of professional settings. CARM provides a framework to study talk-in-interaction in professional settings, identify “trainables,” and deliver those trainables to practitioners.

One premise of CARM is that practitioners in a given professional setting are typically taught interactional skills through contrived role-playing exercises; for example, police officers may practice interviews with simulated suspects (Stokoe, 2014a) or job seekers may practice interviews with simulated prospective employers (Stokoe, 2011). The problem with contrived role-play is the actors do not have the same stakes as real participants; accordingly, the behaviors trained may not be authentic (Stokoe, 2014b). The NTSB stated a similar concern regarding air traffic controller training, “[c]urrent FAA training on emergency handling is formulaic...and does not necessarily incorporate lessons learned from actual events” (2016b, p. 4). CARM seeks to use real recordings of interactions to produce an authentic role-play educational environment (Stokoe, 2014b). Practitioners have reported that attending to such interactions is highly revealing and leads to workplace process improvement (Stokoe, 2011; Stokoe & Sikveland, 2016).

The first step in CARM is to create recordings of naturally occurring data collected from a professional setting. The recordings are transcribed and the dataset is investigated using CA insights and methods to discover areas of practice that may benefit from improvement. Importantly, dataset investigation depends and builds upon a unique relationship between the CA academic seeking to expose systematic patterns of interaction and the practitioner who has expertise in performing their job (Stokoe & Sikveland, in press).

When potential improvement areas are discovered in one interaction, the larger dataset is examined for recurrent trends providing credibility to the original discovery. These discoveries are labelled as “trainables” and are the hard-sought output of the study.

Exemplar recordings and associated transcripts of trainables are extracted from the dataset of real recordings, altering voices when necessary to preserve anonymity. Using positive

and negative examples, altered audio and the associated transcript are synchronized into a presentation tailored to the trainable.

In a classroom setting, student-practitioners are led through the scrollable, audio-synchronized examples. At key points, the scrolling is stopped and the students engage in discussion about what ought to occur next, in terms of effective and successful practice. In other words, they are role-playing. Once the students have discussed the interaction, the scrolling and audio continue providing the students an authentic comparison between what they think ought to happen and what actually did happen, hence the contextualized practice in real-life scenarios (Stokoe & Sikveland, 2016).

Applying CARM to aviation. No literature has been identified that has applied CARM to aviation, though the method is consistent with Tuccio's (2011) suggestion to use re-enactments for authenticity and to evoke emotive responses from learners, as well as CTRBL as defined by Tuccio et al. (2016). Identifying trainables in qualitative data of any domain necessitates a way to organize and query the data to identify trends. The next section discusses coding of qualitative sources.

Qualitative Coding of Media

Language learning studies have developed methods to store and share large volumes of recorded audio and video data. The Child Language Data Exchange System (CHILDES) (<http://talkbank.org>), created in 1981, helped researchers share recorded data and transcripts, which led to advances in methodology and theory (MacWhinney, 2000).

Collegiate and professional sports have developed near real-time relational databases of play video footage. Individual players and team meetings draw upon past plays for review, aided by qualitative coding and hyperlinking of data. Speaking of one commercial software product,

Hudl, Shaer (2016) says, “If a whiteboard and erasable marker were the primary tools of the trade for previous generations of coaches, Hudl is fast becoming the 21st-century analogue” (2nd Section).

Qualitative data analysis software (QDAS) supports qualitative research through the central method of coding, a process of transforming text, audio, and video into emergent concepts and categories (Bazeley, 2006). In this study, the QDAS used is NVivo version 10 (QSR International Pty Ltd, 2014), allowing for one merged database of audio/video content, transcripts of the content,² and multi-level coding of emergent concepts. Significantly, codes are hyperlinked to related segments of original audio/video content (QSR International Pty Ltd, 2010). The results section of this paper shows examples of the QDAS as leveraged in this study.

Coding allows the identification of trainables in the interactional settings previously discussed, as well as identifying diverse samples of actual radio communications. Aviation radio communications and existing ways to learn radio communications are discussed in the next and closing section of this literature review.

Aviation Radio Communications

Clark, Morrow, and Rodvold (1990) examined 36 hours of ATC communications, viewing these communications as conversation that has underlying structure. For radio communications, the conversation structure usually contains transaction initiation, presenting information, and accepting information. Citing the seminal work of Sacks et al. (1974), the authors note how radio communications are transactional, with transactions consisting of sets of turns by participants.

² In this study, Jeffersonian transcripts are made using CLAN software (see MacWhinney, 2000).

Air traffic controllers work from a mental model, processing changing information regarding aircraft and operational conditions. Pilots interpret controller instructions to identify intended actions and update their mental model to match the controller's model. Pilots and controllers are likely to make trade-offs as to the amount of attention they devote to presenting and accepting information (Clark et al., 1990); for example, the earlier example from Excerpt 1 showed pilots disattend (Mandelbaum, 2009)—talk over, pass by—an overheard ATC interaction.

Cardosi (1993) examined 47 hours of ATC recordings to describe the practice of complete readbacks, minimal acknowledgements (i.e., “roger”), requests for controllers to repeat instructions, failure of controllers to detect pilot readback errors, and how multiple information units were conveyed in one transmission by a controller. Similar to the study by Clark et al. (1990), Cardosi used the coding to quantitatively describe the speech acts and problem areas.

Qualitative factors related to problem areas were examined by listening to tapes and examining transcripts. The following relations were observed related to communication errors, though causality was not determined: similar sounding call signs, significant weather, blocked transmissions, controller's fast speech rate, pilot's foreign accent, and non-standard phraseology. Cardosi (1993) concluded with these recommendations (also see Cushing, 1994):

- controllers should keep transmission brief and listen for readback errors;
- pilots should use their call signs when reading back or acknowledging clearances;
- pilots should ask for a repeat of any instruction that is in doubt; and
- pilots should not use readbacks as a method of confirming an instruction that is in doubt.

Methods to learn radio communication skills. Cardosi (1993) offers recommendations for pilots, yet how do pilots develop and maintain radio communication skills? Pilot standards for aviation radio communications in the United States are prescribed in the *Aeronautical Information Manual* (AIM) (FAA, 2016c) and the *Pilot/Controller Glossary* (FAA, 2015b). By following these documents, U.S. pilots will effectively comply with international standards.

Section 4-2-1 of the AIM (FAA, 2016c) related to radio communications states, “[d]iscussion herein provides basic procedures for new pilots and also highlights safe operating concepts for all pilots.” The section then provides guidelines for radio communications including brevity, understanding, listening, thinking before transmitting, microphone technique, and signs of lost communications. Sections 4-2-1 through 4-2-14 of the AIM provide examples of various concepts and scenarios, along with prescriptive phraseology and the phonetic alphabet (FAA, 2016c). Yet the AIM does not suggest practical methods for pilots to learn radio communication procedures and technique. One FAA online learning module delivers the same information as the AIM (FAA, 2006b).

Organizations such as the Aircraft Owners and Pilots Association (AOPA), offer free online, interactive courses, such as *Say it Right* (AOPA, n.d.). This course teaches radio communication principles and techniques using scenarios and actual audio examples.

Commercial endeavors also create learning tools. For example, Kanarish (2013) has a book, website, podcasts, workbooks, and audio clips to help pilots learn radio communications. In the workbook, pilots are presented with tabletop written scenarios where they role-play their response. After completing their response, pilots compare their answer to the one provided in the workbook and the associated audio.

The NTSB has a history of recommendations to the FAA to improve air traffic controller radio effectiveness (2016b). In 2016, in response to five accident investigations, the NTSB recommended that controllers receive scenario-based training based on a continual review of real-world events (NTSB, 2016b).

Intersecting CA and CARM with radio communications. Central to CA's understanding of communication are adjacency pairs, utterances occurring as sequenced such that one makes another relevant, and the moment-to-moment development of interaction of the participants. For an instructional environment, radio talk-in-interaction is constituted by three participants engaging an external party that is often ATC but may be other aircraft or services, the student, and the instructor, as shown in Figure 1. This means for every radio transaction, there is not only the communication between the pilot and the external party, but the likely consequent understanding and activity between the student and instructor. The entire tri-party transaction may provide evidence of the transactional accomplishment.

Figure 1. Participants in radio communication. Adapted from *Beyond the Black Box: Talk-in-Interaction in the Airline Cockpit*, by M. Neville, 2004a, p. 151.

In the context of CARM, it is likely the most effective design of a radio communication trainable will be audio excerpts that capture the talk-in-interaction of all three participants. Role-play of the transactional project includes the intracockpit talk-in-interaction that is an integral part of any radio communication accomplishment.

Study Methodology

The audio/video dataset is being created from two sources: YouTube recordings and direct solicitation of volunteers to record instructional flights (original recordings). Each source is described next.

YouTube

Prolific expansion of YouTube includes a large volume of aviation-related videos. Many aviation videos contain high quality recordings of instructional lessons with premium sound quality. These videos are very often naturally occurring and offer content aligned with the present study. Third party recordings are consistent with the traditions of ethnomethodology and CA (Laurier, 2013).

For the present study, it is necessary to insert excerpts of the audio and video into PowerPoint slides. YouTube use policy only permits content to be used through the YouTube player; as such, content may not be downloaded or screen captured to a form useful for this study (YouTube, 2010).

YouTube content owners were contacted and asked for the original content files that were uploaded to YouTube. At the same time, recorded participants signed informed consent agreements.

Original Recordings

Flight instructors and schools were contacted to identify volunteers willing to audio record and share their instructional flights for the entire time the aircraft intercom was being used. As with archived content, informed consent agreements were signed by instructor and student. A simple, non-intrusive audio recorder and cabling were provided to participants to collect the recordings.

Sample Size

Sample size is not predetermined and follows a saturation point method of sampling (Vogt, 2005). As potential trainables are identified in a sample, additional samples are used to support the repetition of the trainable as an interactional interest. When it is unlikely more will be learned from additional data collection, data collection will cease.

Identifying Trainables

All collected recordings are being iteratively coded, transcribed, and analyzed to identify trainables in the two areas of the study: instructor interactions and radio communications. The first-pass review consists of unmotivated listening/viewing, removal of sensitive/non-pertinent information, notetaking, and broad paraphrasing. During the first-pass review, a grounded-theory nodal structure is being developed through detailed coding of paraphrased content. Consistent with the grounded-theory approach, the nodal structure is constantly evolving based on new observations and interpretations of data (Babbie, 2010).

The second-pass consists of orthographic transcription of areas of interest identified in the first pass along with additional notetaking and nodal coding to identify potential trainable themes. During the first and second pass, radio communications also receive nodal coding. The second pass outputs are shared with a CA professional to elaborate on the potential discoveries

and nodes. With this feedback, third-pass coding creates detailed Jeffersonian transcripts of the identified areas. In the fourth and final pass, data sessions (i.e., collaborative analyses, see Antaki, Biazzi, Nissen, & Wagner, 2008; Hindmarsh & Llewellyn, 2010) review final identified trainables that have emerged, which are then delivered via CARM-based training. The process is summarized in Figure 2.

Figure 2. Process to identify and deliver trainables.

Results

To date, nearly 100 hours of audio and video recordings have been collected and 80 hours have received first-pass coding. Nine trainables have been identified for flight instructor effectiveness, two radio communication prototypes have been developed, Jeffersonian transcription has been performed, four data sessions have occurred, and two trial training

sessions have been performed. Instructor effectiveness trainables include examples in this paper, as well as instructor interactions teaching: the landing flare, an instrument landing system approach, stalls while on autopilot, and radio communication skills. This section describes the development of QDAS coding and hyperlinking, example transcripts, and example trainables.

Qualitative Data Analysis Software (QDAS) Coding

As each audio or video segment is collected, the information is imported into the QDAS. First-pass review of the data is conducted, consisting of paraphrasing of audio content and broad descriptions of video content. Simultaneously, the content is coded using an organically developing node structure, consistent with a grounded theory approach. An excerpt of the current node structure is shown in Figure 3. Alongside each node are aggregate counts of the number of source and content references, helping the analyst identify more prevalent occurrences. Node names are created by the researcher as needed and organized into a hierarchy. Throughout the coding process, nodes are renamed, merged, and reorganized as concepts emerge and new understandings develop (QSR International Pty Ltd, 2010). The ability to perform multilevel coding of one piece of content enables robust searching using analytical queries.

Nodes			
Name		Sources	References
Act-Categorize-pass1		27	1853
Adapt		5	7
Briefing		2	4
Checklist		10	16
Components		1	1
Crew-like interactions		2	2
Environmental		9	36
Error		0	0
Instructor Learn		1	1
Issue		17	585
Learning Evidence		6	16
* * * * *			
Teach		24	595
Teach-Airport, Runway Environment, Takeoff Landing Performance (Unusual)		1	2
Teach-Airspace Awareness		2	13
Teach-Altimeter for IFR approach importance		1	1
Teach-Altitude Awareness		2	9
Teach-Altitude Control IFR		0	0
Teach-approach brief and setup		1	1
Teach-Autopilot Use		1	3
Teach-Basic FMS Operation		2	4
Teach-Basic Level, Climb, Descent, Turn, Level Off (VMC)		4	10
Teach-Body Position (body, feet, head, etc) in plane		1	5
Teach-CDI button on FMS (430)		1	2
Teach-Chandelle		1	13
Teach-Climb Attitude (IMC)		1	2
Teach-Climb Power		1	1
Teach-Complex Aircraft Engine, Power, Prop, gear, fuel pump, Mixture Manage		4	22
Teach-Concept-request approach desired		2	2

Figure 3. Excerpt of grounded theory node structure using NVivo version 10.

Using the QDAS, any node may be opened and the relevant descriptions examined, as shown in Figure 4. Descriptions in this example are the paraphrased content produced during the first-pass examination. To the right of the paraphrased content are coding stripes showing multilevel coding; that is, coding of the same content at other nodes. Although not shown, coding may also be done of full transcription.

Figure 4. Expanded QDAS node using NVivo version 10.

Any of the content shown in Figure 4 may be directly accessed through hyperlinks embedded in the QDAS coding, as shown in Figure 5. Through this mechanism, details contributing to the node may be examined to support apparent trends. Similar to Figure 4, Figure 5 shows coding stripes where the same content (in this case, teaching of Lazy 8s) is coded at other nodes.

Figure 5. Hyperlink from nodal coding to actual content using NVivo version 10.

Source content may have demographic attributes attached, such as geographic location, type of training syllabus, and type of aircraft. Intersections of multiple nodes and attributes may be examined through a variety of queries. For example, to find all student errors holding altitude during instrument syllabus training in a Cessna 172, the matrix coding query shown in Figure 6 may be used. Results of the matrix coding query are shown in Figure 7. All the nodal intersections are active hyperlinks to content summaries and the source audio/video content.

Like all relational databases, the researcher is challenged to develop queries that will return results of interest. Some of these queries are meant to discover relationships, while others are meant to extract known results. Query attempts inform the efficacy of coding choices and often cause a reconsideration of coding, creating an iterative process between querying and coding (QSR International Pty Ltd, 2010).

Figure 6. QDAS matrix coding query design in NVivo version 10.

qry-alt control errors - Results		A : Err-Stu-Altitude Cont...
46 : Err-Stu-Altitude Control	▼	20
63 : Err-Stu-Heading Track	▼	2
99 : Issue-Equipment or Instrument Anomaly	▼	1
107 : No checklist	▼	17
141 : Op-IFR WAAS Glidepath	▼	1
164 : Potential Excerpt	▼	1
170 : Prof Timing-Balance radio, teaching input, fly, manage airplane systems	▼	1
171 : Prof Timing-Coordinate atc & lesson	▼	1
173 : Prof Timing-Teach,fly,situational awareness,error correct~	▼	1
178 : Radio-Alternative Missed Approach Instructions	▼	1
194 : Radio-Busy ATC, waiting for turn	▼	1
198 : Radio-Check in after frequency change	▼	1
200 : Radio-Cleared for IFR approach	▼	1
201 : Radio-Conflict Interruption of Other Radio or Activities	▼	1
215 : Radio-Get weather (AWOS, ATIS, ASOS, Unicom) for destination	▼	2
236 : Radio-Pilot advise controller deviation from assigned	▼	3
275 : Equipment-Radio-Configure to get weather at destination	▼	2
303 : Stu--intercept, track, bracket course	▼	1
309 : Stu-Self Aware of making mistakes	▼	1
322 : Teach-Altitude Awareness	▼	1
324 : Teach-approach brief and setup	▼	1
338 : Teach-Cruise Throttle (Prop) Adjustment	▼	1
369 : Teach-IFR WAAS glidepath	▼	1
378 : Teach-Instructor takes over radio	▼	2
381 : Teach-intercept, track, bracket course	▼	4
394 : Teach-Pace of Operations	▼	1

Figure 7. QDAS matrix coding result in NVivo version 10.

Trends by Domain

Large-scale qualitative data provides numerous dimensions for investigation, which leads to training interventions in the areas of radio communication, deviations from standard operating procedures (SOPs), and interactional events. Identification of each varied dimension requires different levels of expertise. Training interventions are delivered using the CARM-informed technique of a scrollable transcript synchronized to audio or video (Stokoe & Sikveland, 2016).

At key junctures in the event, the scrolling is stopped to allow for student reflection or classroom

discussion, depending on the nature of the excerpt. This method allows for authentic role-play and more intensive learning.

Radio communication examples. Figure 8 shows the starting page of an interactive, self-study radio communications trainer using Microsoft PowerPoint.³ The student can click on any area of interest and start playing the associated audio and scrolling transcript. The online, supplementary material shows how this trainer is used in practice.

Figure 8. Interactive radio trainer home screen.

Audio content includes the radio communications and the associated cockpit interactions. For example, in Figure 9 (Excerpt 1 explains transcription codes used) the aircraft has just departed a non-towered airport in the Washington, DC Special Flight Rules Area (SFRA). The student asks the instructor if he should wait to call Potomac Approach (the approach name in the Washington, DC area). The instructor directs the student to call now, which the student does. At

³ This PowerPoint differs from CARM proper in that it is intended for self-study and has embedded learner prompts.

this point, the audio and transcript stop and the learner is prompted to think about what's next and press the right arrow key to continue. Potomac then replies with "say again," and the radio communication ultimately concludes. After the radio communication, the instructor prompts the student to act upon the altimeter setting.

Non-Towered Airport – First Call to Approach (VFR, SFRA)

Press Right Arrow to Begin →

1	*STU:	gonna get to ah:: (.5) >fourteen< hundred and call them.
2	(1.1)	
3	*INS:	you don't have to wait, you can call 'em now.
5	*STU:	alright.
6	(2.0)	
7	*STR:	.hh Potomac Approach november three three four two zero a:t (.2) one thousand three hundred, off of Freeway.

What's Next? Press Right Arrow →

9	*ATC:	((carrier no voice .9 secs)) callin' approach say again.
10	(1.3)	
11	*STR:	((carrier no voice .7 secs)) november three three four two zero off of Freeway at (.) one thousand (.3) ah:: four hundred. ((carrier no voice .3 secs))
12	(2.3)	
13	*ATC:	november three three four two zero Potomac Approach transponder obser::ved, maintain v f r below bravo airspace, Washington altimeter two niner four zero.
14	(1.6)	
15	*STR:	clear of bravo, four two zero.

And that altimeter... Press Right Arrow →

17	*INS:	yeah^ I think he said the altimeter two nine four zero so,
19	*INS:	probably ought to adjust that a little bit more get that synced up right. (.2) there we go.

Press Right Arrow to Continue →

Figure 9. Sample radio interactive transcript.

This interactive, self-study trainer allows a student to work independently to augment radio learning that is otherwise interactively learned in the actual cockpit. Additional interactive slides can address other areas, such as towered airports and instrument flight rules.

Standard operating procedures. Figure 10 contains an excerpt of a primary student and instructor taxiing back from a lesson at a tower-controlled airport. In line 2, the student initiates talk that is not related to the present task of taxiing the airplane. Used in the setting of an instructor safety meeting, the slide would be stopped after line 2 and instructors asked, "What

should happen next?” A free-ranging discussion may conclude that the instructor in this scenario ought to teach the student to limit off-task conversations during the critical phase of flight (taxi); the general category of SOPs. Thereafter, the remaining lines 3 through 16 are played, showing what actually happened in this scenario. Figure 10 illustrates an important aspect about using inflight recordings: privacy concerns. Even though the participants permitted use of their content for research and training, the excerpt may raise sensitivities; as such, the audio was highly altered and is not included in the on-line supplementary material to avoid any possibility of reverse engineering the alterations.

1	*OTR:	((taxiing to ramp after last landing))
2	*STU:	>alright so what'd'ya need to work on?<
3	(0.7)	
4	*STU:	[beside-besides] the ah altitude on the uhm ((moving hands to explain))
5	*INS:	[()]
6	(2.8)	
7	*INS:	mo-mostly just landings. that's-that's the main thing. is-is landings right now.
8	*STU:	(is that) the next lesson too?
9	(0.6)	
10	*INS:	yep
11	(2.1)	
12	*STU:	[()]
13	*INS:	[()]
14	*INS:	good ground reference you got lucky today. those were- there was no <u>wind</u> to make the ground reference maneuvers challenging.
15	(0.5)	
16	*STU:	() a little bit of tailwind when we were in that ((moving hands to explain)).

Figure 10. Scrollable excerpt related to SOPs.

Interactional events. The prior examples explicate radio communications and SOPs as interactional events, introducing the *conversation analytic* part of CARM: finding evidence in recorded interactions of what is happening in the talk-in-interaction, how together participants collaborate and understand what they are doing. For instructional flights, like the learning

research discussed in the literature review, evidence may point to effective instructional practices and those that are less so, originating from interactional missteps, ambiguous references, or errors. As Stokoe and Sikveland (2016) describe, when these interactional problem areas exist, they often stand out and may be validated by scanning other interactions. Worthy of note, interactional problems occur for everyone at some time and this study does not attribute blame; rather, this study seeks to collect those problems (as well as positive interactions), share them with a larger professional community, and ultimately discover systematic and effective patterns of interaction.

One such interaction identified in the present dataset is what may be called, “not giving the student a chance.” During flight training, there are many good reasons not to give a student a chance, such as, a landing approach gone bad, deviation from altitude on an IFR flight, or slow or improper radio communications. The instructor has a responsibility to understand timing, teaching, safety, and instructional value to decide when to take control from a student.

Excerpt 2 provides an example where the instructor started to give a commercial pilot student a chance to figure out which runway to use for a landing at a non-towered airport under visual flight rules. In lines 1-5, the instructor introduces the problem; then in lines 11-16, the instructor clarifies what frequency must be used to solve the problem. In lines 18-40, the instructor guides the student to look up airport information on an electronic flight bag mobile application. In line 42, the instructor solves the problem for the student, directing him to use runway 23. Presenting Excerpt 2 as a scrollable, pauseable, audiosynchronized transcript to a group of instructors spawns discussion about why the instructor followed the path he did and how further value may have been extracted from the scenario.

Time constraints may also be introduced; that is, Excerpt 2 began when the aircraft was 16 miles from the airport. At line 10, there was an 11-second pause, resulting in line 11 where the student provided an incorrect response evidenced by the instructor reaction in lines 13-15, “no aw not approach.” In line 17, there is another 17-second pause, followed by the instructor intervening again. Line 26 provides another pause, followed by more prescriptive comments by the instructor. Approximately 3 minutes elapsed for the whole exchange in Excerpt 2, a distance of approximately 6 miles, and following this excerpt, the instructor then prompted the student to start his descent (not shown). The instructor may have weighed these time constraints to decide how much time to provide the student to solve the problem or other factors. Nonetheless, the turn-by-turn CA examination provides the basis for in-depth reflection by other instructors. The online, supplementary material shows how this trainer would be used in a classroom setting.

Excerpt 2

Visual Flight Rules Cross-Country Training Flight

- 1 *INS: we actually go ahead and switch (.) our com one over to a traffic
 frequency (were)↘
- 2 (0.2)
- 3 *INS: sixteen miles to go so probably wouldn't be bad to↗ —
- 4 (1.0)
- 5 *INS: see if there's anybody else flying around here figure out which runway their usin'.
- 6 (0.7)
- 7 *INS: plus the wind's calm doesn't really ssss (.4) give us much handle
- 8 (0.6)
- 9 *INS: which way to go.
- 10 (11.0)
- 11 *STU: you're talking about this frequency right?
- 12 (1.2)
- 13 *INS: what's that?
- 14 (1.2)
- 15 *INS: no aw not approach. [() c-taf.] we got. we're good.
- 16 *STU: [(oh)]
- 17 (17.0)
- 18 *INS: how long are those ()-- are the two different runways there?

19 (1.6)
20 *STU: how long are the runways?
21 *INS: yeah.
22 (0.5)
23 *INS: (let's) go back to your airports tab.
24 (1.7)
25 *INS: the runways tab.
26 (6.9)
27 *INS: what'dya got o:::n
28 (1.4)
29 *INS: five two three↗—
30 (1.5)
31 *INS: how long is it?
32 (0.2)
33 *STU: it's ah::: five thousand.
34 (1.0)
35 *INS: how long is the other one?
36 (1.2)
37 *STU: the other one is two thousand [four hundred].
38 *OTR: [(unrelated radio begins)]
39 (1.1)
40 *INS: alright.
41 (1.3)
42 *INS: eh hh let's probably-- let's (.3) probably plan on using runway two three then.
43 (0.7)
44 *STU: okay.

Excerpt 3 shows a situation on an instrument stage check where the check instructor is concerned about the student's knowledge of reverse sensing (not shown, the student is wearing a view-limiting device and cannot see outside). In this case, video recordings were available to show embodied conduct (expressed with ((double parentheses)) in the transcript). In lines 13, 15, 22, 40, 48, 49, 50, 81, and 82, as the check instructor asks and then explains about the concept of reverse sensing, he is moving three instruments fundamental to the student's task: the two course selectors and the heading bug. This is another compelling excerpt that may be replayed with instructors with pauses at key junctures for discussion. For example, after line 13, pausing and asking instructors, "what's next?," will create authentic role play. By the time

pauses happen around line 80, the instructors watching the replay of Excerpt 3 will begin to anticipate the check instructor's movement of key instruments and reach conclusions about their own and most effective behavior in similar circumstances. These conclusions may be when an instructor changes instruments on behalf of the student, the student's situational awareness may be impaired. The online, supplementary material shows how this trainer would be used in a classroom setting.

Excerpt 3

Intercepting a Radial on an Instrument Training Stage Check

12 *INS: alright let's pr↑oceed (1.0) heading three six zero:: (1.4)

13 a::nd interce::pt (1.3)
((INS touches course selector #1 knob))

14 *INS: the:: one ze::ro ze::ro degree radial outbound from the Crestview

15 VOR. ((INS dials course selector #1 from 120 to 100))

16 *STU: okay.

17 *INS: so we've i- (.) ideed an (0.6) a::n ah:: (0.7)
we're monitoring

18 because we've got the nav flags right?

19 *STU: right.

...

22 *INS: [now we use (0.3) both
((INS dials course selector #2 knob to 100))
of these to do that (.) one zero zero:.

...

28 *INS: no:w are we gonna get (.) positive sensing, (.) on the CDI?

29 *STU: ((clears throat))

30 *STU: positive sensing?

31 *INS: yeah.

32 *INS: meaning that (0.8) that (0.2) if we have to correct le:ft (0.3) it'll
33 correct left (.) or if we have to correct w- right (.) it'll correct
34 right.

35 *INS: but (0.8) but are we gonna get positive sensing or
36 reverse sensing?

- 37 *STU: I don't know.
38 *STU: honestly I don't know.
39 *INS: okay well
40 *INS: ((INS begins to move course selector #2 from 100 towards 280))
41 *INS: u::m (1.1) two eight zero (1.3) inbound (2.1)
((INS finishes moving
42 course selector #2 to 280))
to the Crestview VOR,

43 *INS: () okay we cn (.) lead turn a little bit (0.2) and
44 start our turn to the r:: right
45 *INS: ((coughs))
46 *INS: to the right (.) you're clear right (1.2) and we're gonna track
47 ou:tbound on the one zero zero.
48 *INS: ((INS starts to set heading bug on directional gyro))
49 *INS: an you can set the (0.5) one zero zero on yr heading ((INS completes
50 setting heading bug)) jus so you have somethin to look at.

...
...
81 *INS: so let's come over to zero nine one:
((INS moves heading bug on
82 directional gyro)) and what we'll do is we'll bug it,

Discussion and Conclusions

Designedly large-scale qualitative studies involving the use of audio and video recordings of training flights provide an opportunity to study interactions and develop study-based interventions. Nodal QDAS coding creates a query-able database of interactional events that helps identify trends that may be verified with hyperlinking to actual content. Suppositions about trends are then verified through micro-detailed Jeffersonian transcription and CA analyses. Validated suppositions are then formed into the CARM delivery method. As Stokoe and Sikveland (in press) state, “It [CARM] shows how what we refer to as ‘designedly large-scale

qualitative research’ can create impact and underlines the clear differences between CA and more traditional qualitative forms of inquiry” (last paragraph).

Collected recordings provide large volumes of coded and readily retrievable radio interactions. In the training environment, many of these interactions include tri-party exchanges between instructor, student, and the external participant (usually, but not always, ATC; see Figure 1). While it is a straightforward exercise to convert radio recordings to interactive slides, optimizing the learning value of the excerpts is an open question that warrants further investigation using CA. Limited trials and feedback of the radio trainer have received favorable feedback; however, more quantitative study with larger numbers of participants is necessary to evaluate effectiveness and improve thereupon.

Figure 10 provides an excerpt that is a comparison of actual practice to SOPs. Generally, SOPs are another area that may lead to many training interventions. For example, the dataset has yielded a set of best practices that flight instructors recommend students perform that may otherwise be lost to the ephemeral, in-the-moment environment of the flight deck.

Excerpts 2 and 3 are markedly CA-discovered findings. Trends are observed in the QDAS, and then micro-detailed transcriptions evidence the central themes. A cursory look at Excerpt 2 may not reveal the theme of “not giving the student a chance,” yet through the process of Jeffersonian-detailed transcription, the key turns in talk leading to the lost opportunity for the student become apparent (e.g., line 1-5, 11-16, and finally line 42). When presented using CARM to instructor practitioners, the excerpt makes for a compelling, interactive learning encounter with potential to improve teacher effectiveness.

Many observations may be made with audio recordings alone. Excerpt 3 benefited from video to show instructor pointing, touching, twisting, and gestures germane to the analysis and

any ultimate training intervention. As described for “not giving the student a chance,” an instructor practitioner stepping through synchronized transcription, audio, and video with strategic pauses surfaces Excerpt 3’s features; creating compelling, memorable, and authentic role-play for training. Naming trainables in memorable and engaging ways also helps identify the CARM episode; for example, Excerpt 3 is *CARM-alized* into “don’t touch my stuff.”

Thus far, only one beta training session has occurred with instructors, which included Excerpts 2 and 3. Group discussion following Excerpt 3 indicated a strong affiliation between the CARM induced role-play and instructor individual experiences. Instructors noted how the confusion could be avoided and self-reflecting on their own experiences. The beta test lacked generalizability; however, the group dialogue and self-reflection were consistent with other CARM environments (Stokoe & Sikveland, 2016).

Future Work

Over time, more data will be collected and subsequently coded, mined, and examined using CA. Trainables will be extracted for varied radio communications scenarios of increasing complexity. Instructional scenarios based on SOP deviations and interactional events will be identified and CARM-alized into trainables. Individual exemplars will be compared to identify systematic patterns of interaction that may be generalized to create communication strategies for instructors grounded in actual interactions.

While CARM has proven to be a “tried-and-tested method” (Stokoe & Sikveland, in press, last paragraph) in various non-aviation domains, future work in the aviation training environment will seek to validate the domain transference. Validation of Kirkpatrickian levels of learning (reaction, learning, behavior, and results) will ultimately need to occur (Tuccio, 2013).

Coding of interactional events in the QDAS will continue to evolve through an iterative process of querying, discovery, and node and attribute refactoring. Ultimately, this nodal evolution is expected to result in a robust taxonomy, perhaps drawing upon existing aviation-based taxonomies (Stolzer et al., 2008). As the dataset and QDAS coding nodes grow, challenges of data management and backward compatibility of inevitable software upgrades may be a concern (Inmon, O’Neil, & Fryman, 2007).

The aviation training environment is a primordial site of interaction, error, and repair because students are learning new and complex skills and, by necessity, must encounter and respond to error. Comparing prior aviation CA work of professional flight crews (Arminen & Auvinen, 2013; Dismukes, Berman, & Loukopoulos, 2007; Nevile, 2004a) with the primary training environment, error rates in primary training are significantly higher and—in some actual recording in the present datasets—nearly continuous. Data-driven qualitative work in the present primary training environment can lead to innovations useful to a number of training areas from FIRC’s to air traffic controllers to professional flight crew training programs, such as AQP’s.

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