Pair Analytics and Joint Action Theory:
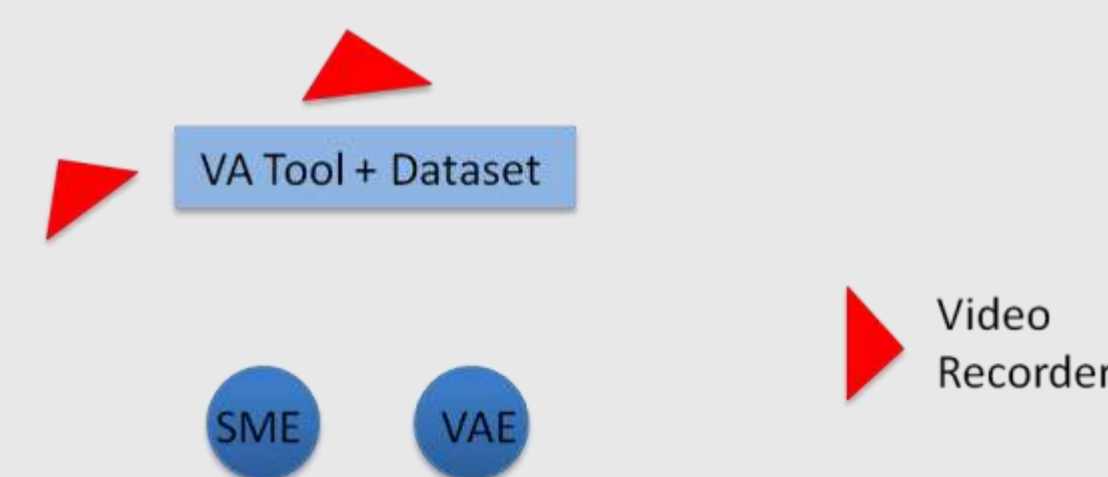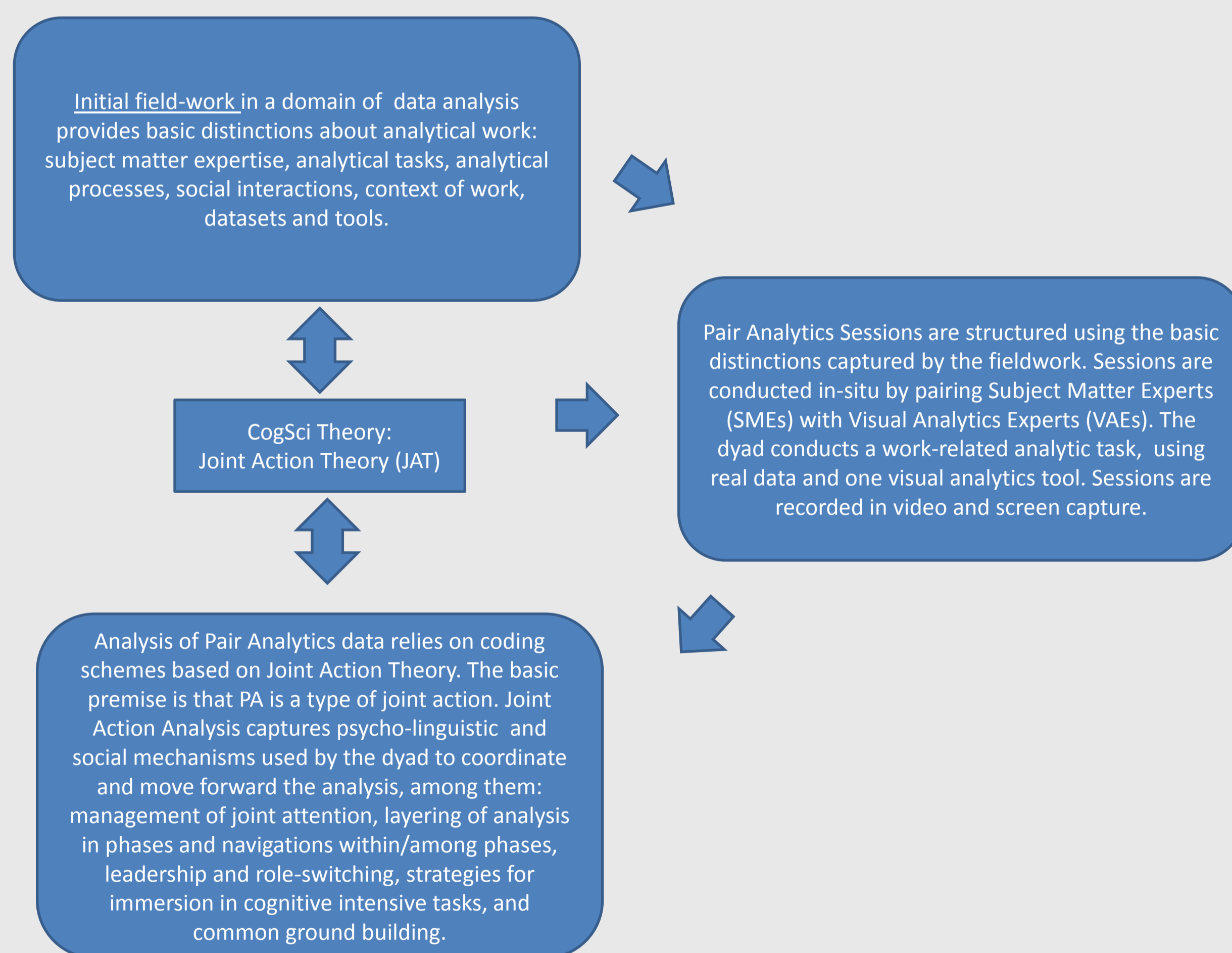
A Research Protocol to Study Cognition and Interaction in Visual Analytics

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METHOD

Pair Analytics (PA) is a method that generates verbal data about thought processes in an "in-vivo" human-to human interaction with visual analytics tools. A pair of analysts conducts in-situ real analytic tasks, using real datasets and a visual analytics tool. Data about visual analytic reasoning, collaboration in analytical work and analytic discourse is captured by using coding schemes based on Herbert H. Clark's Joint Action Theory (JAT).

CONDUCTING PAIR ANALYTICS

Initial field-work in a domain of data analysis provides basic distinctions about analytical work: subject matter expertise, analytical tasks, analytical processes, social interactions, context of work, datasets and tools.

CogSci Theory: Joint Action Theory (JAT)

Pair Analytics Sessions are structured using the basic distinctions captured by the fieldwork. Sessions are conducted in-situ by pairing Subject Matter Experts (SMEs) with Visual Analytics Experts (VAEs). The dyad conducts a work-related analytic task, using real data and one visual analytics tool. Sessions are recorded in video and screen capture.

Analysis of Pair Analytics data relies on coding schemes based on Joint Action Theory. The basic premise is that PA is a type of joint action. Joint Action Analysis captures psycho-linguistic and social mechanisms used by the dyad to coordinate and move forward the analysis, among them: management of joint attention, layering of analysis in phases and navigations within/among phases, leadership and role-switching, strategies for immersion in cognitive intensive tasks, and common ground building.

TESTING PAIR ANALYTICS

- Initial fieldwork and semi-structured interviews with commercial aircraft maintenance experts were conducted. Product: analytical task, datasets, and recruiting of SMEs.
- Four SMEs participated in six Pair Analytics Sessions with one VAE from our lab using TABLEAU, a visual analytics tool.
- We used data collected in these sessions to test the validity of pair analytics using JAT to capture cognitive phenomena.

CAPTURING COGNITIVE PHENOMENA WITH PA/JAT

1. Navigation of analysis -- project markers: We observed some variation in the use of verbal markers when combined with body motion and intonation. For example, "right", when accompanied by small, repetitive head nods and an upward intonation functions as an acknowledgment token and continuer (horizontal marker). When "right" is uttered with no head nod, or a large head nod possibly followed by a few small nods and a downward intonation, it serves as an agreement token and vertical marker.

2. Navigation of analysis -- Appropriation of VA tool and computer as psycho-linguistic resources for joint action: We observed stable patterns of interaction with the history feature of TABLEAU that co-occurred with changes in analytical paths. Every time an analytical path was exhausted to the point of arriving at an insight or a dead-point, the "saving-state-of-analysis" behavior was always produced. This behavior can be conceptualized as a non-verbal marker [placing] that signals the transition to a next phase of analysis.
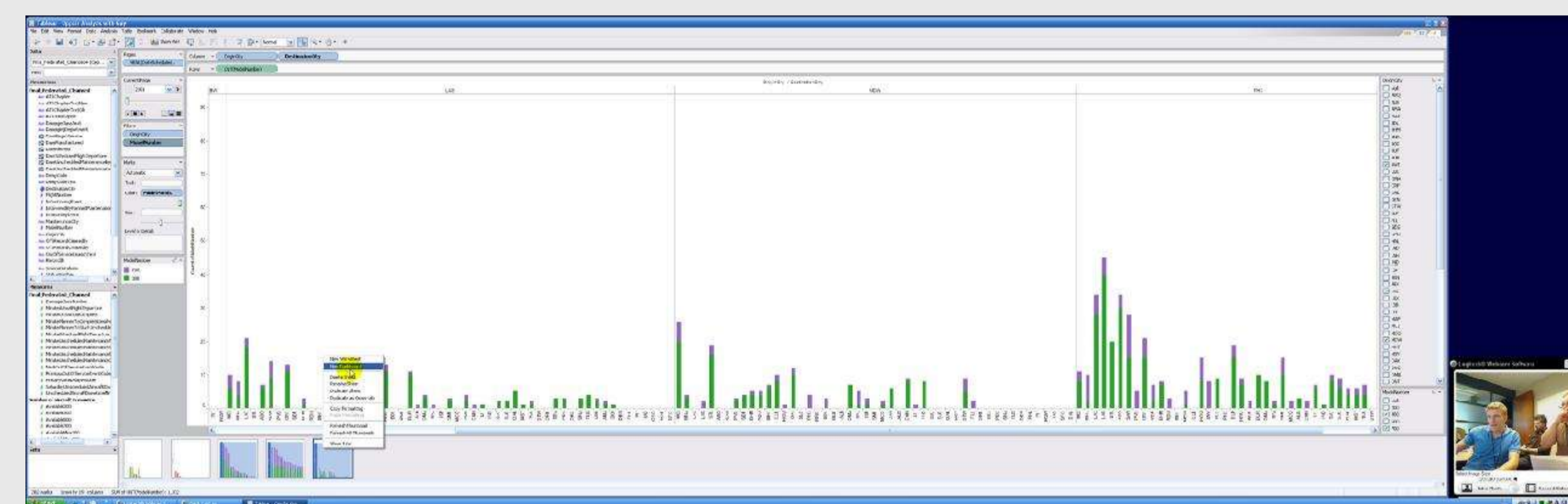
3. Cognitive workload: We noted that while most of the individual participatory actions sustain a continuous flow of interaction between participants, some of these actions demand a pause in the human-to-human interaction. The pause is empirically observed as a "thinking-aloud" event, in which one participant stops her engagement in dialogue and utters words to the computer screen. These pauses reflect the effects of high cognitive demands on participants generated by the specific interaction with the data/visual analytic tool. It seems that "thinking-aloud" serves a double purpose here: to create a temporary isolation from dialogue to concentrate on the task at hand while informing the other participant about the state of the individual participatory action to avoid interruptions.

4. Mutual monitoring of cognitive states -- Joint attention: We observed that participants monitor each other's perceptual and cognitive attention and provide verbal and non-verbal cues to capture/ direct joint attention and to confirm whether joint attention is in place or not:
   a) Finger-pointing is used by speakers to direct attention to a specific location in the visual representations of the data [directing].
   b) Mouse-pointing is used (1) as indicator, in the same way as finger-pointing, when used by the speaker[directing]; and (2) to provide a visual cue that attention is placed on the speaker's intended referent, when used by the listener[confirming].

IMPROVING PAIR ANALYTICS

Problems:
1. Explanatory dialogue and Analytic dialogue contain stark differences.
2. Joint Action Theory analysis is time intensive.
3. The data has been transformed. The SME needs to be re-acquainted with it in the new format.

Solutions:
1. Focus analysis only on Analytic dialogue.
2. Structure data collection and Joint Action Theory coding around specific research questions/concepts.
3. Run a data information session before the Pair Analysis exercise to reintroduce the data to the SME.

RESEARCH QUESTIONS TO BE EXPLORED FURTHER

For Pair Analytics:

- Is pair analytics more effective than other methods for capturing reasoning processes such as protocol analysis?
- Is pair analytics both a valid and a reliable method for cognitive studies of visual analytic reasoning?
- What other cognitive phenomena can be better captured by pair analytics when informed by cognitive science?

For Collaborative Visual Analytics from a Joint Action Theory perspective:

- Can we incorporate markers of human-computer interaction and coordination devices for design of mixed-initiative, visual analytics systems?
- Can we empirically deduce insight generation from HCI by focusing on GUI components that have been appropriated as coordination devices?
- Can we facilitate, by design, the use of GUI components as psycholinguistic mechanisms to coordinate joint attention?

MAIN REFERENCES

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Researchers:

Richard Arias-Hernandez, Ph.D.

Linda T. Kaastra, Ph.D.

Brian Fisher, Ph.D.

SCIENCE Lab

For further information please contact ariasher@sfu.edu