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**Cindy L. Menches, Ph.D., P.E. and Juan Chen**

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# A diary study of the disruption experiences of crew members on a jobsite

Cindy L. Menches, Ph.D., P.E., M.ASCE[1] and Juan Chen, M.S., M.ASCE[2]

**Abstract**

This article demonstrates the use of a diary technique in a construction setting. The advantage of a diary study over other methods for capturing subjective experience is its ability to capture the thoughts, decisions, actions, and emotions of individuals *in situ* – while they are working in their natural setting – at multiple points in time during an individual's workweek. Hence, the diary method is uniquely designed to answer questions about group-level trends as well as individual behavior. The specific goal of the study reported in this article was to derive an understanding of the types of fast decisions and actions that are made following a workflow disruption and how the disruption impacts the worker's state of mind. The analyses revealed that there was a group-level positive correlation between experiencing a disruption and initiating a fast improvised decision and action. However, some workers tended to improvise frequently when disrupted while others did not. The analyses also revealed that the workers' emotions fluctuated throughout the week, and two emotions – *determined* and *interested* – tended to decline following a disruption. But, some of the workers also experienced increases in their negative emotions while others did not, suggesting that not all workers react in the same way to disruptions. Consequently, the diary technique provides a novel way to identify the impact of disruptive events on worker decision-making and performance.

**Subject Headings**: decision making, disruptions, emotions, construction workers

[1] Assistant Professor, Department of Civil, Architectural, and Environmental Engineering, Illinois Institute of Technology, 3201 S. Dearborn Street, Chicago, IL 60616; 312-567-3630; E-mail: cmenches@iit.edu
[2] Graduate Research Assistant, Department of Civil, Architectural, and Environmental Engineering, Illinois Institute of Technology, 3201 S. Dearborn Street, Chicago, IL 60616; 312-567-3630; E-mail: jchen35@hawk.iit.edu

## 1. Introduction to Diary Studies: A focus on individuals

Construction is generally characterized as a time-dependent, uncertain process consisting of episodes of productive work, interruptions, waiting, and fast improvisational decision-making. In this environment, levels of turbulence, time-pressure, and affect (i.e., mood or emotions) fluctuate throughout the day and will influence the degree to which a worker feels productive and achieves continuous work flow. As a result, these episodes of productive work and disruptions make up the daily experience of a construction worker on the jobsite. But, little is known about the moment-to-moment experiences of workers because capturing data "in-the-moment" while workers are performing their tasks poses significant research challenges. As a result, a great deal of construction research has tended to use cross-sectional research methods that employ surveys or retrospective interviews in order to identify common characteristics of groups of construction workers (Barta and Tennen 2008). However, while cross-sectional research methods aid in identifying group-level phenomena, there may be times when a researcher would like to identify and understand phenomena that occur at the individual person-level. For example, a researcher might be interested in determining how the frequency of disruptions relate to the time pressure felt or stress level experienced by construction workers. A cross-sectional method would likely use retrospective survey techniques or interviews to ask workers to rate how much time pressure or stress they typically feel when their work task is disrupted. Then a correlation can be performed to identify whether greater frequency of disruptions is positively related to higher stress levels across workers. In contrast, a person-level analysis can uncover rich detailed information about the specific types of disruptions that influence the amount of time pressure or stress experienced by each specific worker, and how other factors relate to these phenomena, such as the worker's personality or the length of the disruption. A person-level approach thus makes it apparent that various phenomena on the jobsite occur as "consequences of causal strings of unique events" and such "causal strings" can be studied to determine their impact on worker decision-making and performance (Barta and Tennen 2008).

An excellent way to collect momentary data at the individual person-level is by conducting a diary study. A diary study engages individuals in recording their momentary experiences, including tasks, thoughts, emotions, decisions, and actions, in order to gain insight into their behavior over time and in a natural setting. Diary studies employ an idiographic approach to the study of behavior, where an idiographic approach focuses on intensive, fine-grained analysis of individual behavior, the environment in which it occurs, factors that influence individual behavior over time, and its consequences (Barta and Tennen 2008). Although diary studies have been used extensively in sociology, psychology, and healthcare (Ben-Zeev et al. 2010; Csikszentmihalyi 1997; Stone et al. 2002), their use in business settings has occurred only recently (Miner and Glomb 2010; Snir and Zohar 2008; Szollos 2009). Consequently, this paper contributes to the growing body of research on diary studies conducted in natural business settings. Specifically, the primary purpose of this paper is to demonstrate the use of a diary technique in a construction setting by reporting the results of a study that investigated the impact of workflow disruptions on the individual decisions, actions, thoughts, and emotions of five workers on the same construction site and how their decisions, actions and emotions differed.

### 1.1. Idiographic, nomothetic, and idiothetic approaches to the study of workers

In psychological research, a strong debate has been underway for at least the past two decades on the best approach to study individual differences in the way people think, feel, and

make decisions. Proponents of comparative methods prefer a nomothetic approach to the study of people, where "nomothetic" refers to the traditional between-persons analysis of individual characteristics (Pelham 1993). For example, a nomothetic approach could be used to investigate the relationship between the frequency of disruptions experienced by workers and the workers' average level of frustration, where one would expect to see an increase in frustration as the number of disruptions increases. In contrast, proponents of individual uniqueness prefer an idiographic approach to the study of people, where "idiographic" refers to "analyses of the patterned uniqueness that exists within the person" – i.e., a within-person analysis (Allport 1937). For example, an idiographic approach could be used to investigate how a worker's frustration level fluctuates in response to disruptions throughout the day. Hence, one of the primary distinctions between nomothetic and idiographic approaches is, respectively, the emphasis on between-persons comparisons versus within-person (time-dependent) comparisons (Pelham 1993). Lamiell (1981) proposed a hybrid method termed "idiothetic" – that is, the research is idiographic in the sense that it captures multiple data points from a single person over time and the research is also nomothetic in the sense that is seeks to confirm general characteristics between-persons. In fact, modern statistical analysis techniques – especially multi-level modeling – have made hybrid *idiothetic* approaches to the study of people significantly more popular in recent years. While this paper uses an idiographic technique to understand how different electrical construction workers on the same jobsite react individually to workflow disruptions, a nomothetic approach is used to understand the reaction of the group of workers, as a whole, to chronic task disruptions – thus resulting in an *idiothetic* approach to the study of the workers' disruptions, decisions, actions, and emotions.

### 1.2. The Diary Study Technique as a novel method for studying construction workers' disruptions, decisions, actions, and emotions

Methods for studying subjective experiences, such as thinking or mood, can generally be divided into three categories: (1) retrospective self-report surveys, (2) interviews, and (3) diary studies. The advantage of a diary study over other methods for capturing subjective experience is its ability to capture the thoughts, decisions, actions, and emotions of individuals *in situ* – that is, while they are working in their natural job setting. Furthermore, diary methods capture data at multiple points in time during an individual's workday and workweek, thus capturing fluctuations in productive work, interruptions, mood changes, fast decision-making, and action-implementation. Hence, the diary method is uniquely designed to capture the moment-to-moment subjective experiences that make up the construction workers day and week.

Diary studies generally employ a technique called Ecological Momentary Assessment (EMA), in which workers complete real-time brief momentary assessments of their decisions and actions on a paper form or on a digital device at random times throughout the workday (Menches and Chen 2012). As a result, an EMA method allows workers to systematically and repeatedly report on their experiences in real-time and in jobsite settings, across time and across contexts (Shiffman et al. 2008). A unique characteristic of any EMA method is the use of alarms to signal participants at various times throughout the day to stop what they are doing and fill out the momentary assessment form on the digital device (i.e., a personal digital assistant (PDA) or smartphone). The self-assessment form is designed to capture both external and internal dimensions of experience (Hektner et al. 2007), where external dimensions include date and time alarmed, physical location at the moment alarmed, physical activities at that moment, and other persons the participant is with. These questions form the *context* of the worker's momentary

experience. The internal dimensions of experience, on the other hand, are measured by questions about the participant's thoughts, feelings, and decisions as the participant performs various work activities and/or interacts with other people (Nielsen and Cleal 2010).

The EMA method permits the nearly instantaneous recording of participants' location, activities, thoughts, and moods, thus increasing the possibility of capturing specific phenomena, such as a task disruption and the worker's step-by-step physical and behavioral response to the disruption. Consequently, the likelihood of identifying decisions, actions, and emotions resulting from a task disruption is significantly greater than if taking retrospective reports at a later time (such as during an interview at the end of the day or week) in which recall bias is more likely to interfere with the participant's ability to accurately remember the sequence of decisions and actions. Thus, diary techniques – and the EMA method in particular – capture patterns of decisions and actions throughout the day and week (Teuchmann et al. 1999), thus allowing researchers to identify, for example, disruptions and decisions that impact daily productivity, mood states, and job satisfaction. Because disruptions occur frequently on the jobsite and workers' reactions to these disruptions vary with the event, an EMA method makes it possible to capture the fluctuations in these unplanned-for disruptions and the resulting emotional reaction, fast decisions, and actions as they occur "in the moment."

## 2. A study of crew members' disruptions, decisions, and reactions on a single jobsite

Currently, there is no study that links within-person variation in disruptions on the construction site to within-person variation in impromptu actions or emotional reactions. Yet, evidence suggests that a worker's decisions and actions vary across time in an effort to adapt to uncertain conditions on the jobsite (Miner and Glomb 2010; Miner et al. 2005; Teuchmann et al. 1999). The study of behavior at work (i.e., decisions, actions, and emotions) is complicated by its transient nature – decisions and actions are episodic while emotions vary across time (Beal et al. 2005). In fact, Miner and Glomb (2010) note that "it is hard to envision a workday where a single mood state or single behavior is maintained all day." Consequently, the study of disruptions, decisions, and reactions is best studied using a within-person approach, and as a result, a diary technique was selected for the study because it is uniquely structured to address the question of how construction workers react and adapt to task disruptions throughout the workday.

The primary goal of the current study was to derive an understanding of the types of fast decisions and actions that are made following a workflow disruption and how the disruption impacts the worker's state of mind. As such, the study investigated the types of disruptions experienced by a crew of electrical construction workers all working on the same jobsite, and how each individual adjusted their actions "in-the-moment" in response to the various disruptions. The study also examined how these disruptions and impromptu adjustments to their work influenced their emotional state throughout the workweek.

The remainder of this article presents the results from using a diary technique that employs an EMA method for addressing questions about how five construction workers on the same jobsite reacted to task disruptions and how these workers often engaged in improvisational decision-making in order to minimize the impacts of chronic disruptions.

### 2.1. Research purpose and questions

The study presented in this paper was part of a federally-funded research program designed to investigate how workers adapt to daily workflow disruptions by improvising their decisions

and actions. The study participants were five electrical construction journeymen that varied in age and experience. The study aimed to identify how each of the five workers reacted and adapted to workflow disruptions by evaluating the worker's subjective internal experience (i.e., judgments, emotions, and decisions) as well as their planned and improvised activities (i.e., external experience). The study also aggregated the data to evaluate the reaction of the group as a whole to chronic daily disruptions.

To better understand how the group of electrical construction workers as a whole reacted to disruptions on the jobsite, the *nomothetic* analyses addressed the following between-persons questions:

1. How did the average percentage of disruptions across the week influence the average percentage of improvisational decisions and actions that occurred during that week? In other words, is there evidence that the workers adjusted their activities "in-the-moment" to adapt to daily unexpected working conditions?
2. How did the average percentage of disruptions across the week influence the workers' average mood states during that week?

Furthermore, to better understand how a single worker reacted to disruptions on the jobsite, the *idiographic* analyses addressed the following within-person questions:

1. How did the decisions and actions of each specific worker differ when the worker had been disrupted versus when the worker had not experienced a disruption? Specifically, did the worker engage in greater improvisational decisions and actions when they experienced a disruption as opposed to when they had not been disrupted?
2. How did disruptions influence each specific worker's state of mind throughout the day and week? Specifically, did their mood states change following a disruption?

The results of the *idiothetic* study of construction electricians are presented below.

### 2.2. Methodology

Electrical construction workers from the Chicago metropolitan area were recruited to participate in the study. One company nominated a large project for participation in the pilot study, and as a result, six journeymen electricians and three foremen were selected from among over 35 electrical construction workers to participate. The activities of the foremen and the journeymen are significantly different; hence, only the journeymen were included in the study reported in this paper. Although six journeymen participated, one of the digital devices failed during the data collection, and the worker's data were lost. The remaining five journeymen's data were used for the analyses.

The data collection cycle involved (1) training the workers to use the digital devices (i.e., PDA), (2) collecting self-reports (i.e., momentary assessments) on the PDA from each worker for one week, (3) retrieving the devices and downloading the data, (4) studying the data and creating printouts for the exit interviews, and (5) conducting the exit interviews. Hence, the first stage of the data collection process involved training the workers on how to use the digital devices to complete the momentary assessments (i.e., surveys) and what to do if the device failed. The training occurred on Monday morning of Week 1 just prior to the start of work (around 6:30 AM). Two researchers met with the workers (i.e., participants), with one researcher explaining the procedures while the other researcher demonstrated the operation of the device. The researchers explained the procedures and asked the workers to complete one trial survey on the device. As the workers conducted the trial run, the researchers explained each question and demonstrated how to make their selection from among the multiple choice questions.

Following the training, the workers placed the PDA in a carrying case, attached the carrying case to their belt, and went to work. The devices were programmed to send five alarms per day to the workers between the hours of 7:30 AM and 3:00 PM. An alarm was programmed to beep at a random moment within five 1.5-hour windows (7:30-9, 9-10:30, 10:30-12, 12-1:30, and 1:30-3). The alarm sounded for five minutes to give the workers enough time to complete their task, determine whether it was safe to respond, and then respond to the survey. The digital survey was designed to permit the worker to respond to all of the questions in three minutes or less. At the end of each day, the workers returned the devices to the construction office, where they were plugged into an electrical source to be charged overnight. The next morning, the workers retrieved their device and continued responding to alarms. At the end of the week, a researcher returned to the site to collect the devices from the workers. The following week, the researchers conducted exit interviews to discuss the results of the data collection effort with the workers.

### 2.3. The digital survey questions

Because the digital survey was designed to permit the worker to respond to all of the questions in three minutes or less, the questions included only multiple choice answers with no open ended responses. The survey consisted of four sections, including (1) context questions, (2) questions when disrupted, (3) questions when not disrupted, and (4) state of mind questions. The PDA was programmed so that the workers only answered the "questions when disrupted" if they responded that they had been disrupted since they were last alarmed. If they indicated that they had not experienced a disruption, the PDA was programmed to present only the "questions when not disrupted."

*Context Questions.* The context questions asked the workers about their location, who they were with, whether they experienced time pressure or turbulence, and whether their work had been disrupted since they were last alarmed.

*Questions When Disrupted*. The "questions when disrupted" asked the workers about the severity of the disruption, type of disruption, and whether the disruption caused them to work on the same or different task. Workers were also asked to identify the type of task they were working on before and after the disruption, how similar the new task was to the original task, how much time was spent on making the decision to alter the task, and how much thinking (i.e., cognitive effort) was necessary to make the decision.

*Questions When Not Disrupted*. Similarly, the "questions when not disrupted" were nearly identical to the "questions when disrupted" but were asked under the assumption that any deviation from the planned work task was essentially voluntary rather than being caused by a disruption to the work. For example, a worker might decide to change the work method because they believed they could perform the task more efficiently using a modified method.

*State of Mind Questions*. The state of mind questions asked workers about a variety of positive and negative emotions experienced as a result of the disruption or at the moment they received the alarm. The four negative emotion words included nervous, angry, disgusted, and irritable. The four positive emotions words included determined, interested, alert, and confident.

## 3. Results from the idiothetic study of crew members' disruptions, decisions, actions and emotions

The results consist of a between-persons analysis of the aggregated data as well as the within-person individual analyses. While the between-persons analysis identified the *trends* in improvised decision-making and emotional reactions across the five workers on this jobsite as

well as the *patterns of behavior* (i.e., how this group of construction workers reacted as a whole to the workflow disruptions), the within-person analysis answered questions about *how* each worker reacted to disruptions. Consequently, the idiographic approach examined the time-dependent relationship between experiencing a workflow disruption and the specific reaction of each worker (i.e., degree of improvisation and emotional reaction).

### 3.1. Worker Demographics and Project Characteristics

Each participant was assigned a pseudonym (i.e., "assigned name") for the purpose of discussing their results for this paper. The assigned name and demographic characteristics of each participant are presented in Table 1. All participants were journeyman electricians and had previously completed a four-year apprenticeship program. The average age of the workers was 40 and ranged from 29 to 52. Three of the workers characterized themselves as Caucasian, while one worker (Subject 2: Samuel) was self-described as black and one (Subject 4: Ricardo) was Hispanic. Two workers (Subject 2: Samuel and Subject 3: Aaron) had less than one year of experience as a journeyman electrician, two workers (Subject 1: Bruce and Subject 5: Lloyd) had more than five but less than 10 years of experience as a journeyman electrician, and one worker (Subject 4: Ricardo) had more than 15 years of experience as a journeyman. All five workers had some level of college education, and Subject 3 (Aaron) was a four-year college graduate.

**Table 1.** Participant Demographics

| Subject ID | Name | Position | Age | Race | Experience | Level of Education |
|---|---|---|---|---|---|---|
| 1 | Bruce | Journeyman | 37 | Caucasian | 5 - 9.9 years | Some college or tech school |
| 2 | Samuel | Journeyman | 34 | Black | 0 - 12 months | Some college or tech school |
| 3 | Aaron | Journeyman | 29 | Caucasian | 0 - 12 months | College graduate |
| 4 | Ricardo | Journeyman | 52 | Hispanic | 15 - 19.9 years | Some college or tech school |
| 5 | Lloyd | Journeyman | 49 | Caucasian | 5 - 9.9 years | Some college or tech school |

The following questions were asked about the characteristics of the project and how these characteristics relate to the subjective experience of the electricians.
1. Rate the level of complexity of the project you are working on.
2. Rate how stressful you find the work atmosphere to be overall on this project.
3. Rate how challenging you find the work to be on this project.
4. Rate the level of skills you feel you need to complete the work on this project.

The following responses were possible: (1) low, (2) moderately low, (3) medium, (4) moderately high, and (5) high. On average, the electricians felt the level of complexity of the project was medium, but there was significant variation among responses. Subject 1 (Bruce) felt the complexity was moderately high while Subject 3 (Aaron) felt the complexity was low. Furthermore, the subjective experiences also varied among the workers. The average level of stress and challenge felt by the workers was rated as moderately low while the average level of skills needed to complete the work was rated as medium. However, Aaron – the only college graduate – may have felt under-challenged by the work, as evidenced by his rating of "low" to most of the questions. Likewise, Ricardo – the most experienced worker – also assigned lower ratings, on average, than the other workers.

### 3.2. Response Rates

During the week, each electrician received 25 alarms that signaled them to fill out a momentary assessment survey. While the average response rate was 76%, the response rates varied widely. Two electricians (Subject 1: Bruce and Subject 2: Samuel) responded to all 25 alarms (i.e., response rate = 100%). Subject 5 (Lloyd) responded to 80% of the alarms (20 out of 25) and Subject 4 (Ricardo) responded to 72% (18 out of 25). However, Subject 3 (Aaron) only responded to 28% of the alarms (7 out of 25), which is significantly fewer than the other electricians. In fact, the average response rate among the other four workers was 88%. Hence, Aaron's low response had a significant impact on the average response rate, which highlights the impact that a single participant can have on the aggregated results when the sample size is small. Hence, in instances when the data from one participant significantly impacts the aggregated results, the aggregated data should be supplemented with individual analysis to better *explain* the outcome.

### 3.3. The pattern of workers' disruptions during the week

One of the goals of the study was to capture instances of disruptions and the participants' decision, actions, and emotional reactions to the disruptions. Hence, the analysis began with a summary of the percentage of times that each worker responded to an alarm and indicated that they had experienced a disruption. Table 2 presents the summary analysis. The average percentage of time that the group of electricians was disrupted was 28% of the reported time. However, Subject 4 (Ricardo) experienced the greatest number of disruptions, indicating that he was disrupted eight out of the 18 times he responded to the alarm (44%). In contrast, Subject 3 (Aaron) was disrupted the fewest number of times, indicating he was disrupted one out of the seven times he responded to the alarm (14%). The remaining participants were disrupted a similar percentage of time: Subjects 1 and 2 (Bruce and Samuel) were disrupted seven out of 25 responses (28%), and Subject 5 (Lloyd) was disrupted five out of 20 responses (25%).

**Table 2.** Percentage of Reported Disruptions

| Subject ID | Assigned Name | Percent of Reported Disruptions |
|---|---|---|
| 1 | Bruce | 28% |
| 2 | Samuel | 28% |
| 3 | Aaron | 14% |
| 4 | Ricardo | 44% |
| 5 | Lloyd | 25% |
| AVG | | 28% |

The *specific disruptions* experienced by the workers were also analyzed nomothetically and ideographically. The electricians were presented with a list of 10 possible disruptions and were asked to identify the source of the disruption (from the list) each time they responded to an alarm and indicated that they had experienced a disruption. The average types of disruptions experienced by the electricians as a group included (Figure 1): (1) lack of materials, tools, or equipment needed to perform the task (16%); (5) lack of help from someone else (3%); (7) change of sequence (5%); (8) rework (11%); (9) someone (another trade, co-worker, or supervisor) interrupted my workflow (36%); and (10) other (30%). The data show that the most frequent disruption experienced by the electricians was a task disruption caused by some other

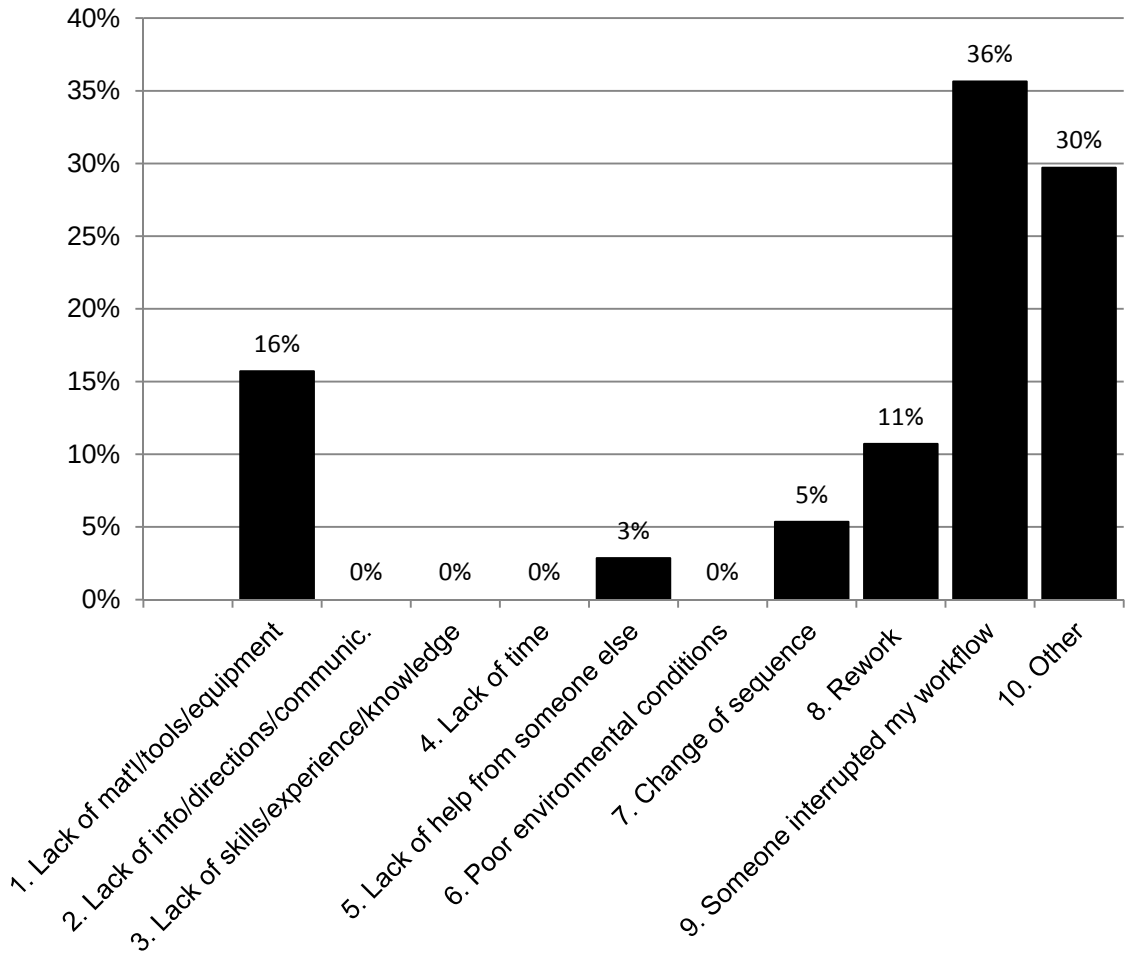


**Figure 1.** Types of disruptions experienced by the crew of electricians

person on the jobsite. In fact, an examination of the individual (i.e., idiographic) data revealed that four of the five electricians reported at least one instance of being disrupted by someone on the jobsite (Table 3), and three of the workers listed "disrupted by someone else" as the *main* source of their disruption (i.e., during more than 50% of the times they reported being disrupted). Interestingly, Subject 4 (Ricardo) was most significantly impacted by a lack of tools, materials, or equipment (50% of his reported disruptions), and each worker (other than Subject 3: Aaron) reported multiple sources of disruptions across the workweek. Hence, while disruptions caused by other workers on the jobsite were the largest source of task disruptions in general, a variety of other causes of disruption were also noted by the five crew members.

### 3.4. The pattern of fast decisions made, and actions taken, in response to disruptions

To investigate how the journeymen's decisions and actions changed (i.e., whether they improvised) when they had been disrupted versus when they had not been disrupted, the researchers analyzed their responses to the following questions:

1. (When disrupted) How different is your new task (following the disruption) from your planned task?
2. (When not disrupted) How similar is your current task to your planned task?

**Table 3.** Types of Disruptions Experienced

| Type of Disruption | Average | Subject ID | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1. Lack of materials/tools/equipment | 16% | 14% | 14% | 0% | 50% | 0% |
| 2. Lack of information/direction/communication | 0% | 0% | 0% | 0% | 0% | 0% |
| 3. Lack of skills/experience/knowledge | 0% | 0% | 0% | 0% | 0% | 0% |
| 4. Lack of time | 0% | 0% | 0% | 0% | 0% | 0% |
| 5. Lack of help from someone else | 3% | 14% | 0% | 0% | 0% | 0% |
| 6. Poor environmental conditions | 0% | 0% | 0% | 0% | 0% | 0% |
| 7. Change of sequence | 5% | 14% | 0% | 0% | 13% | 0% |
| 8. Rework | 11% | 0% | 29% | 0% | 25% | 0% |
| 9. Someone interrupted my workflow | 36% | 57% | 29% | 0% | 13% | 80% |
| 10. Other | 30% | 0% | 29% | 100% | 0% | 20% |
| TOTAL | 100% | 100% | 100% | 100% | 100% | 100% |

The possible answers to these questions included: (1) I am performing the *same* task with *no* adjustments, (2) I am performing the *same* task but made *minor* adjustments, (3) I am performing the *same* task in a *significantly different* way, (4) I am performing an *entirely different* task in the *standard* way, and (5) I am performing an *entirely different* task that required a creative *workaround*. These questions explored how the disruptions (or lack of disruptions) impacted the journeymen's ability to complete their assigned tasks as planned. The assumption made by the researchers was that the decision to select a totally new or different task that requires a creative (i.e., non-standard) completion method (Response 5) is more improvisational than performing the same task as planned with no adjustments (which requires no improvisational decisions or actions) (Response 1). Hence, the ordering of the responses reflects the increasing degree of improvisational decisions and actions that might be taken when disrupted or when not disrupted in order to remain productive, where the ordering of improvisation can be thought of as none (Response 1), minor (Response 2), moderate (Response 3), substantial (Response 4), and total improvisation (Response 5).

*Nomothetic Analysis.* The between-persons analysis was conducted by first aggregating the response-level data (i.e., each of the 25 responses to the self-report surveys) and then by examining how the *average* percentage of reported disruptions across the week was associated with the *average* percentage of reported improvisational acts that occurred across the week for each worker. Table 2 (previous) identified that, on average, the group of journeymen reported being disrupted during 28% of their self-assessments. Furthermore, Table 4 identifies that, on average, the group of journeymen reported improvising their activities during 23% of their self-assessments, with one worker reporting no improvisational acts and one worker reporting improvisational acts 44% of the time. A correlation analysis was performed between the average percentage of disruptions per worker (Table 2) and the average percentage of improvisational acts per worker (Table 4, Column 2) using Spearman's rho (a non-parametric measure of statistical dependence between two variables) because the sample size was small. The results indicated that the correlation between percentage of disruptions and percentage of improvisational acts was 0.975, suggesting a statistically significant relationship between being disrupted and improvised decision-making ($p = 0.005$).

To further explore how the context influenced improvisational decision-making, the data was divided into two types of responses per person: "when disrupted" and "when not disrupted." The

**Table 4.** Frequencies of Disruptions and Improvised Actions

| (1) Subject ID | (2) Percent of Improvised Acts Reported for All Self-Reports | (3) Frequency of Reported Disruptions | (4) Frequency of Reported Improvised Acts | (5) Percent of Improvised Acts When Disrupted | (6) Frequency of Reports of No Disruptions | (7) Frequency of Reported Improvised Acts | (8) Percent of Improvised Acts When Not Disrupted |
|---|---|---|---|---|---|---|---|
| 1 | 32% | 7 | 7 | 100% | 18 | 1 | 6% |
| 2 | 28% | 7 | 2 | 29% | 18 | 5 | 28% |
| 3 | 0% | 1 | 0 | 0% | 6 | 0 | 0% |
| 4 | 44% | 8 | 8 | 100% | 10 | 0 | 0% |
| 5 | 10% | 5 | 2 | 40% | 15 | 0 | 0% |
| AVG | 23% | 5.6 | 3.8 | 54% | 13.4 | 1.2 | 7% |

researchers compared the average percentage of improvisational acts per worker when the worker reported being disrupted and when the worker reported not being disrupted in order to determine whether there was an association between a greater number of workflow disruptions and a greater number of improvisational acts. Table 4 presents the percentage of time that each worker responded that they had adjusted their task (i.e., improvised) either (1) when they were disrupted (Column 5), or (2) when they had not been disrupted (Column 8). The workers, on average, reported improvising their tasks 54% of the time that they were in a disrupted state; in contrast, the workers reported improvising only 7% of the time when they were not in a disrupted state. A two-sample comparison using the Mann-Whitney U Test (a non-parametric test used to determine whether the mean of two groups are different from each other) was statistically significant ($p = 0.05$), indicating that the journeymen tended to improvise their decisions and actions more often when they were in a disrupted state.

Hence, in response to the question, "Does the average percentage of disruptions across the week influence the average percentage of improvisational decisions and actions that occurred during that week?" – the between-persons analysis suggests that, *for this crew on this jobsite*, the answer is yes. An examination of the data demonstrated that disruptions were often followed by the initiation of improvised decisions and actions.

*Idiographic Analysis.* The diary study technique, in which each worker responded to multiple surveys to report their disruptions, decisions, actions, and emotions, made it possible to address questions about whether each worker engaged in a greater number of improvised acts when they experienced a disruption as opposed to when they had not been disrupted. This question suggests that disruptions and decisions fluctuate throughout the workday, resulting in a potentially time-dependent and causal relationship between specific disruptions and subsequent decisions and actions. Consequently, recording each worker's disruptions and reactions at several moments in time permitted the researchers to not only *describe* the phenomenon reported by the workers (i.e., that disruptions influenced their improvised actions) but also to *explain* their behavior (i.e., which specific type of disruption influenced the specific degree of the improvised action). Thus, by examining the data in this way, it was possible to determine whether there was an association between each worker's experience of being disrupted and their decision to take fast (i.e., improvisational) actions in order to continue working.

An examination of the frequencies of each worker's reported disrupted and non-disrupted experiences and their corresponding reports of improvised actions when disrupted and not disrupted (Table 4) demonstrated that:

1. Subject 1 (Bruce) improvised a new task (i.e., he performed an entirely different task) or he improvised his work method (i.e., he performed the *same* task but made adjustments) 100% of the time he reported being disrupted; that is, every time Bruce experienced a disruption, he improvised a whole new task or improvised a new method for completing his disrupted task. Likewise, in only 6% of the instances when Bruce was *not* disrupted, he reported improvising his task or his work method – that is, he frequently (94% of the time) performed exactly the same task that he was scheduled to work on and he performed it in the usual way when he was not disrupted. Furthermore, a within-person correlation between Bruce's disrupted states and his degree of improvisational decisions and actions resulted in a very strong positive correlation between being disrupted (yes/no) and degree of improvisational decisions and actions (none/minor/moderate/substantial/total improvisation) ($r = 0.900$, $p = 0.000$).
2. Subject 2 (Samuel) improvised a new task or he improvised his work method only 29% of the time he reported being disrupted. Similarly, in 28% of the instances when Samuel was *not* disrupted, he reported improvising his task or his work method. Consequently, Samuel was likely to employ improvisational actions about the same percentage of time when in a disrupted or non-disrupted state. In fact, he tended to improvise less often than the other workers when disrupted and more often than the others when not disrupted. Furthermore, a within-person correlation between Samuel's disrupted states and his degree of improvisational decisions and actions identified no significant correlation between being disrupted and degree of improvisational decisions and actions ($r = -0.039$, $p = 0.853$).
3. Subject 3 (Aaron) did not report any instances of improvising a new task or work method either when he reported being disrupted or when he reported not being disrupted. Possible reasons for this result might include the low overall number of responses captured via the diary technique or Aaron's general reluctance to improvise his actions. No definitive conclusions can be drawn about Aaron's tendency to improvise his actions on the jobsite.
4. Subject 4 (Ricardo) improvised a new task or work method 100% of the time he reported being disrupted, and he reported *no* improvisational acts when he was not disrupted. That is, whenever Ricardo was disrupted he tended to improvise, and when he was not disrupted, he did not tend to improvise. Furthermore, a within-person correlation between Ricardo's disrupted states and his degree of improvisational decisions and actions resulted in a very strong positive correlation between being disrupted (yes/no) and degree of improvisational decisions and actions (none/minor/moderate/substantial/total improvisation) ($r = 0.955$, $p = 0.000$).
5. Subject 5 (Lloyd) improvised a new task or work method 40% of the time he reported being disrupted, and he reported *no* improvisational acts when he was not disrupted. That is, when Lloyd was disrupted, he tended to improvise fairly often (i.e., 40% of the time), and when he was not disrupted, he did not tend to improvise at all. Furthermore, a within-person correlation between Lloyd's disrupted states and his degree of improvisational decisions and actions resulted in a relatively strong positive correlation between being disrupted and degree of improvisational decisions and actions ($r = 0.577$, $p = 0.008$).

Another insightful way to *explain* the workers' improvisational behavior is to examine a time series plot of their daily self-assessments to identify how each type of disruption influenced the specific degree of the improvised action that followed the disruption. Figure 2 shows an example

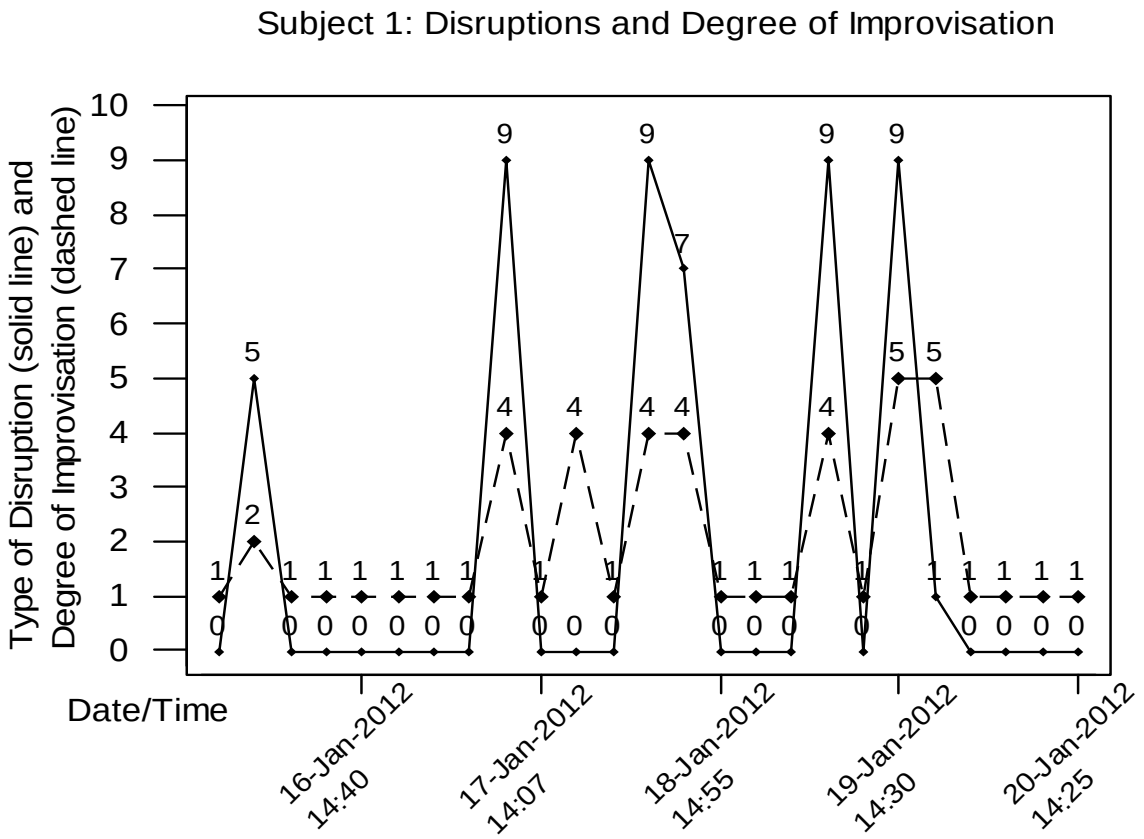


**Figure 2.** Example time series plot for Subject 1 (Bruce) showing how the degree of improvisation fluctuated with the type of disruption over the week

of a time series plot for the 25 self-assessments provided by Subject 1 (Bruce) during the week that data was collected. The plot shows the fluctuations in disruptions using a solid line, where the numbers indicate the specific type of disruption experienced (e.g., 9 = Someone interrupted my workflow; see Table 3). The time series plot shows that on Monday, Bruce was disrupted by a lack of help; on Tuesday, Wednesday, and Thursday, he was interrupted by another person; on Wednesday, Bruce was also impacted by a change in sequence; and on Friday, he experienced a lack of tools, materials, or equipment. During each of these disrupted experiences, the dashed line clearly shows that Bruce also improvised his decisions and actions. Again, the number specifies the degree to which he improvised (1=none, 2=minor, 3=moderate, 4=substantial, and 5=total). On Monday, when Bruce experienced a lack of help from someone else, he made a minor adjustment but continued working on the same task. On Tuesday, Wednesday, and Thursday, in response to being interrupted by another person or experiencing a change in sequence, Bruce performed an entirely different task but he was able to use a standard method to complete the new task. On Friday, when he experienced a lack of tools, materials, or equipment, Bruce performed an entirely different task and also had to develop a creative method for completing the new task. Consequently, the time series plot provided much more fine-grained detail about the conditions that caused disruptions across the week and Bruce's behavioral response.

Similar plots (not shown here) were created to examine the relationship between disruptions and improvised decisions and actions for each of the four other workers on this jobsite.

Subject 2 (Samuel) reported seven total disruptions. On Monday, he reported one instance of being disrupted by another person and two instances of being disrupted for some other reason, but he did not report performing any improvised acts as a result of these disruptions. He reported no disruptions on Tuesday but reported one instance of being disrupted by another person on Wednesday as well as one instance of not having the tools/materials/equipment needed to complete his task. Again, neither of these disruptions resulted in an improvised act. No disruptions were reported on Thursday but on Friday, Samuel reported two disruptions that required him to perform rework, and these two disruptions caused Samuel to execute a minor improvised act, that is, he perform the *same* task he was scheduled to work on but he made *minor* adjustments.

Subject 3 (Aaron) reported only one disruption, which happened on Monday. He stated that the cause of the disruption was some "other" reason, and he did not report improvising a decision or action as a result of the disruption; instead, he continued working on exactly the same task with no adjustments. No other disruptions or improvised acts were reported.

Subject 4 (Ricardo) reported eight disruptions during the week. On Monday, Ricardo was disrupted three times by a lack of tools/materials/equipment and in all three cases he performed an entirely different task that required a creative workaround. On Tuesday, Ricardo was disrupted twice by another person, and both of these disruptions caused him to perform an entirely different task but he completed the task in a standard way. On Wednesday, Ricardo was again interrupted by a lack of tools/materials/equipment and he again performed an entirely different task that required a creative workaround. On Thursday, he experienced a change in sequence to his work, and as a result, he continued working on the same task but had to make minor adjustments. On Friday, Ricardo was disrupted for some other reason, and this unspecified disruption caused him to perform an entirely different task but he was able to use a standard method.

Subject 5 (Lloyd) reported five disruptions during the week. He did not report any disruptions on Monday, but on Tuesday, Lloyd reported being disrupted for some other reason and the disruption did not cause him to improvise a decision or action. On Wednesday, Lloyd reported two instances of being disrupted by another person, and each time, he had to perform an entirely different task either in a standard way or by creating a workaround. On Thursday, he again reported two instances of being interrupted by another person, but in these two instances, he was able to continue working on exactly the same task as planned (i.e., he did not improvise). Lloyd had no self-assessments for Friday.

### 3.5. The pattern of affective states following disruptions

To investigate how the journeymen's state of mind (i.e., emotions) differed when they had been disrupted versus when they had not been disrupted, the researchers analyzed their responses to the following questions:

1. Rate how irritated/nervous/disgusted/angry you felt as a result of the disruption (or how irritated/nervous/disgusted/angry you are feeling right now, if not disrupted)?
2. Rate how confident/alert/interested/determined you felt following the disruption (or how confident/alert/interested/determined you are feeling right now, if not disrupted)?

The possible answers to these questions included: (1) not at all, (2) a little, (3) moderately, (4) quite a bit, and (5) extremely. These questions and responses explored how significantly the disruptions (or lack of disruptions) impacted the journeymen's negative and positive emotional states during the week.

*Nomothetic Analysis.* The between-persons analysis was conducted by first aggregating the response-level data and then by examining how the *average* percentage of disruptions across the week was associated with the *average* rating of negative and positive emotions that occurred across the week. A correlation analysis was performed between the average percentage of disruptions per worker and the average rating of each specific emotion per worker using Spearman's rho. The results indicated that there was *no significant correlation* between percentage of disruptions and average rating of each specific emotion by the workers ($p > 0.05$ in all cases).

However, to further explore how the context influenced the journeymen's affective states, the data was again divided into two types of responses per person: "when disrupted" and "when not disrupted." The researchers compared the average rating of negative and positive emotions when the workers reported being disrupted and when the workers reported not being disrupted in order to determine whether there was an association between a greater number of workflow disruptions and a change in positive and negative emotional states. A two-sample comparison using the Mann-Whitney U Test was statistically significant ($p < 0.05$) for the positive emotion *determined*, and an examination of the data indicated that the level of determination decreased following a disruption for four out of the five workers. Similarly, a Mann-Whitney U Test approached a level of significance ($p = 0.059$) for the positive emotion *interested*, and an examination of the data indicated that the level of interest declined following a disruption for four out of the five workers. No other associations between disruptions and emotions were found.

Therefore, in response to the question, "Does the average percentage of disruptions across the week influence workers' average mood states?" – the (context-specific) between-persons analysis suggests that, *for this crew on this jobsite*, the answer is partly yes and partly no. Two positive emotions (determination and interest) tended to decline following a disruption but no other changes in positive or negative emotions were detected across the workers.

*Idiographic Analysis.* To evaluate the relationship between each worker's emotional state and their disrupted experiences, the researchers conducted a within-person correlation between each worker's state of disruption (i.e., disrupted/not disrupted) and eight emotions (four negative and four positive). The findings suggest that, while emotions are often influenced by disruptions, individuals vary significantly in their emotional reaction to being disrupted.

1. Subject 1 (Bruce): A within-person correlation between Bruce's disrupted state and eight emotions identified a significant negative correlation between disrupted state and level of interest ($r = -0.472$, $p = 0.017$), indicating that when Bruce was disrupted, his level of interest declined. No other associations between disruptions and emotions were found.
2. Subject 2 (Samuel): No significant associations between disruptions and emotions were found. And while Samuel experienced modest mood fluctuations throughout the day and week, his changes in mood did not appear to be specifically associated with being disrupted.
3. Subject 3 (Aaron): A within-person correlation between Aaron's disruptions and emotions identified a significant negative correlation between disrupted state and level of determination ($r = -0.764$, $p = 0.046$), indicating that when Aaron was disrupted, his level of determination declined. No other associations between disruptions and emotions were found.
4. Subject 4 (Ricardo): A within-person correlation between Ricardo's disruptions and emotions identified a significant negative correlation between disrupted state and *all positive emotions*: level of confidence ($r = -0.582$, $p = 0.011$), level of alertness ($r = -0.506$, $p = 0.032$), level of

interest (r = -0.460, p = .055), and level of determination (r = -0.506, p = 0.032). These findings indicate that when Ricardo was disrupted, his level of positive emotions declined overall, but disruptions did not impact his level of negative emotions. Overall, Ricardo reported that he felt little or no irritation, nervousness, disgust, or anger, even when disrupted.

5. Subject 5 (Lloyd): No significant associations between disruptions and emotions were found. In fact, Lloyd's self-assessments suggest that his emotions were very stable throughout the day and week.

Another way to *explain* the workers' fluctuations in emotions across the week is to examine a time series plot of daily self-assessments to identify how each type of disruption influenced specific negative and positive emotions. Figure 3 presents an example for Subject 4 (Ricardo), in which Ricardo's ratings of his level of confidence during the week are superimposed on a time series plot of his disruptions during the week. As described previously, the plot shows the fluctuations in disruptions using a solid line, where the numbers indicate the specific type of disruption experienced (e.g., 9 = Someone interrupted my workflow; see Table 5). Ricardo's plot is especially interesting because a close examination of the plot makes it apparent that each time Ricardo experienced a disruption caused by a lack of tools, materials, or equipment (Type 1), his level of confidence dropped sharply. Other types of disruptions caused little change in his level of confidence, which remained relatively high for most of the week. This might be an indication that Ricardo did not feel confident he would be able to complete his task when he lacked tools, materials, or equipment. A similar pattern emerged when comparing his disruptions to his other positive emotions (alertness, interest, and determination). His positive emotions declined significantly when he lacked the tools, materials, or equipment needed to complete his task. An examination of Ricardo's disruptions and his negative emotions revealed that his level of irritation, nervousness, disgust, and anger remained stable and low during the week and did not appear to be influenced by disruptions.

Similar plots (not shown here) were created to examine the relationship between disruptions and emotions for each of the four other workers on this jobsite.

Subject 1 (Bruce) experienced fluctuations in negative emotions throughout the week. However, his fluctuations in negative emotions did not coincide with instances of being disrupted, thus indicating that being disrupted did not trigger an increase in the level of irritation, nervousness, disgust, or anger. Bruce's positive emotions were stable throughout the week, except for one instance on Friday. During this self-assessment, Bruce reported being interrupted by another person, and as a result, all of his positive emotions (confidence, alertness, interest, and determination) declined dramatically.

Subject 2 (Samuel) reported fairly stable emotions throughout the week in spite of his disruptions. However, at the end of the week, when he was required to perform rework a second time, his level of irritation and disgust increased dramatically and his level of anger increased slightly. Furthermore, Samuel's level of interest was rated as moderate in the early part of the week (Monday through Wednesday) but increased to "extremely interested" on Thursday and Friday, possibly indicating that he had changed tasks and was performing work that he found more interesting later in the week.

During Subject 3's (Aaron's) single disruption on Monday, he experienced a sharp increase in his level of irritation and a moderate increase in his level of disgust and anger, but his level of nervousness did not change, which was constant and low all week. Likewise, his level of interest

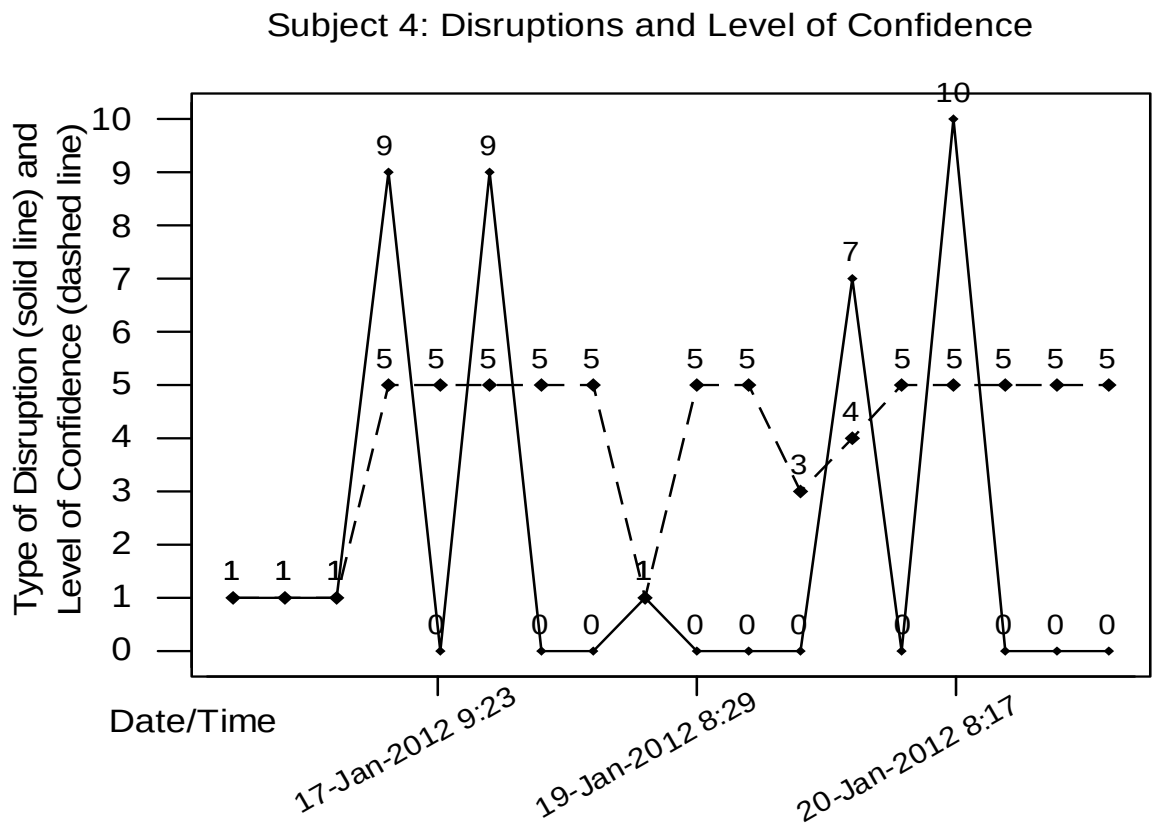


**Figure 3.** Example time series plot for Subject 4 (Ricardo) showing how his level of confidence fluctuated with the type of disruption over the week

and determination declined dramatically when he was disrupted, but his level of confidence and alertness did not change, which were constant and high all week.

Subject 5 (Lloyd) experienced five disruptions during the week, but these disruptions did not influence his negative emotions, which remained low and stable all week. Likewise, his positive emotions were high and stable all week and were not influenced by his disruptions.

## 4. Discussion and Conclusion: Using the diary technique to study the disruption-decision-action cycle

As mentioned in the introduction, the primary purpose of this paper was to demonstrate the use of a diary technique by reporting the results of a specific diary study that investigated the impact of workflow disruptions on the decisions, actions, thoughts, and emotions of five workers on the same construction site. While a significant amount of construction research has tended to focus on identifying trends in processes or patterns of behavior among people (e.g., a group of construction workers), the diary technique provides a way to describe and explain phenomena that occur at the individual person-level. Consequently, the diary technique can address questions of how construction workers react and adapt to task disruptions throughout the workweek.

Specifically, the analyses revealed that there was a group-level positive correlation between experiencing a disruption and initiating an improvised decision and action, meaning that, as a whole, *this group of construction electricians on this jobsite* tended to improvise their decisions and actions when they experienced a disruption. However, three of the electricians tended to improvise frequently when disrupted while the other two workers did not. Furthermore, certain

types of disruptions – *anecdotally* – triggered certain types of improvisation. For example, interruptions by another person *and* disruptions caused by a lack of tools/materials/equipment often caused the journeymen to work on an entirely different task (i.e., execute a substantial or total improvisation). Additional data collection and analysis from other workers on other jobsites, using the diary technique, might provide more definitive evidence that specific types of disruptions trigger specific types of improvisational decisions and actions.

The analysis also revealed that the workers' emotions fluctuated throughout the day and week, and a negative group-level correlation was identified between disruptions and two emotions – *determined* and *interested* – where the levels of determination and interest tended to decline following a disruption. No group-level correlation was identified between disruptions and negative emotions. But, clearly some of the workers experienced momentary increases in their negative emotions (e.g., increases in their level of irritation), suggesting that not all workers react in the same (perhaps calm) way to workflow disruptions. Furthermore, specific workers tended to experience more frequent disruption-related momentary changes in emotions, possibly suggesting a three-way relationship between personality, reactions to disruptions, and changes in emotions, which could be examined further by collecting additional data from other workers on other jobsites.

Hence, a diary technique provides a single method for collecting multiple data points from multiple construction workers at multiple points in time, thus providing researchers with a flexible way to examine not only the trends in processes and behaviors but also specific instances of phenomena that occur as "consequences of causal strings of unique events." The diary technique, as a result, provides a novel way to identify the impact of such unique events on worker decision-making and performance.

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