# Impacts of Disruption on Secondary Task Knowledge: Recovery Modes and Social Nuances

Christoph Oemig
Human-Computer Interaction Group
University of Bamberg
Bamberg, Germany
coemig@acm.org

Tom Gross
Human-Computer Interaction Group
University of Bamberg
Bamberg, Germany
tom.gross@uni-bamberg.de

## Abstract

The working memory of the human brain has always had a strong influence on the design of Human-Computer Interaction. Yet, it is limited in capacity and loses its contents over time. Research regarding these constraints typically focused on single user tasks and systems. Collaborative settings and systems introduce the need for the secondary task of coordination which shares the same conditions and constraints as the knowledge of the primary task. Additionally, it is easily compromised by interruption and interference. Our approach seeks to understand the impacts of disruption on secondary task knowledge, but from a different angle than previous related work. Since it is hard to avoid disruption entirely, it aims to understand how users recover from disruptions in order to help them recover the best way possible from different types of interruptions using appropriate mechanisms and cues. This paper reports on the results of one of the first experiments along the way, observing the effects of four types of interruptions revealing different modes of recovery and social nuances that inform the design of adaptive coordination support systems.

## CCS CONCEPTS

Human-centered computing→HCI design and evaluation methods

## KEYWORDS

Awareness, Coordination, Disruption, Assessments.

**ACM Reference format:**

Christoph Oemig and Tom Gross. 2019. Impacts of Disruption on Secondary Task Knowledge: Recovery Modes and Social Nuances. In Mensch und Computer 2019 (MuC'19), September 8—11, 2019, Hamburg, Germany. ACM, New York, NY, USA. 4 pages. https://doi.org/10.1145/3340764.3344914


*MuC '19*, September 8–11, 2019, Hamburg, Germany

ACM ISBN 978-1-4503-7198-8/19/09…$15.00
https://doi.org/10.1145/3340764.3344914

## 1 Introduction

The working memory of the human brain has always had a strong influence on the design of Human-Computer Interaction. Two major aspects especially triggered research activities: one being the working memory's limited capacity and the other being the loss of its contents over time. Forgetting is a natural mechanism that keeps our memory from overloading. Research in terms of forgetting started with Ebbinghaus and his forgetting curves [4] and even accompanies us today as part of recommender systems [2] or popular apps like Snapchat [1], where it contributes the major incentive to share personal information. Yet, in the past the research focus was usually on single user tasks and systems. Collaborative settings, however, introduce a need for the secondary task of coordination that in turn requires and produces its own type of knowledge (i.e., secondary task knowledge) regarding the situation at hand. Unfortunately, this knowledge has to share the already limited capacity of the working memory with the knowledge about the primary task (e.g., the creation of a shared document). Secondary task knowledge is critical to a team's success as it allows effective and efficient collaboration. The consequences of problems in this area result in coordination errors that, for instance, cause different people to do the same task twice.

Secondary task knowledge is stored subconsciously and due to its ephemeral nature, it is easily compromised by interruption and interference. Related work suggests a strong effect of interruptions on a collaborative task due to the impact on the secondary task knowledge located in the working memory. Yet, the major effort of scientific work focused on minimizing the disruptiveness [3], i.e., finding the right time and manner for interruptions, or understanding the role of context on the cost of interruption [7]. However, from our point of view interruptions can hardly be avoided or optimised entirely. Particularly in cooperative scenarios the goal is to enhance the interplay of the primary task and the secondary task for effortless coordination [6]. Therefore, we do not necessarily focus on how to minimize the impacts of disruptions. We rather seek to find new ways helping users to recover the best way possible from various types of interruptions during their collaborative task using appropriate mechanisms and cues. As there are different types of interruptions (some of which we introduce later) this at least calls for adaptive coordination support mechanisms as a counter measure.

This paper reports on the results of one of the first experiments along the way measuring the distinct levels of secondary task knowledge of participants before and after four different types of interruptions as well as during their process of recovery following these interruptions. It leverages on the Standardised Coordination Task Assessments (SCTA)[9], a method and tool for evaluating primary and secondary task knowledge in a collaborative context. Participants are provided a standard task and they are queried using a specific set of questions to assess the status of primary and secondary task knowledge by determining and recording levels of correctness and speed related to these questions. Besides that, observations during that experiment revealed different modes of recovery and social nuances on how participants dealt with the results of interruptions. These insights will serve as the basis for the next series of experiments to evaluate different ways to restore secondary task knowledge after interruptions depending on the type of interruption thus informing the design of adaptive coordination support systems.

## 2 Approach

Gaining a deeper understanding of the impacts of disruption on a participant's secondary task knowledge requires its measurement before and after these interruptions. Assessing the process and state of recovery requires at least a third measurement. Additionally, an appropriate primary task is needed in order to create a need for coordination that in turn creates secondary task knowledge that can be observed and assessed. The primary task needs to be standardised (i.e., it should be of the same type and cause the same workload) as it should not become a variable in the experiment. Therefore, we utilized the method of Standardised Coordination Task Assessments (SCTA) [9] and its tools. Here, a group of participants has to engage in the task of collaboratively counting individual letters inside a shared document. While appearing to be very abstract at first sight, this primary task can be recreated very easily and quickly being equivalent in terms of type and workload at the same time.

The primary task's shared document is automatically created by the SCTA tool according to pre-set parameters (e.g., number of participants, max. duration of counting, max. number of letters etc.). During the task it is shown to each participant individually (cf. Figure 1). The group needs to coordinate the counting effort, i.e., where and how to start and to continue. Counting results (e.g., a=5, b=7 etc.) have to be shared among the group. They also have to be submitted to the tool where they are recorded centrally as data triplets (letter, timestamp and participant). As secondary task knowledge is ephemeral by nature, determining its status requires its measurement in situ to capture the necessary information. For this reason, the SCTA tool applies freeze probes (also referred to as freeze technique [5]), i.e., suspending the counting task and querying each participant about it, at configurable points in time (in this case the aforementioned three). The questions used by freeze probes are provided by the SCTA tool automatically based on the previously recorded counting results. Participants are asked group- ("Who counted letter X?") and artefact-related questions ("Was the letter X counted?"). On the other end the knowledge of the actual number of letters inside the document belongs to the primary task knowledge.

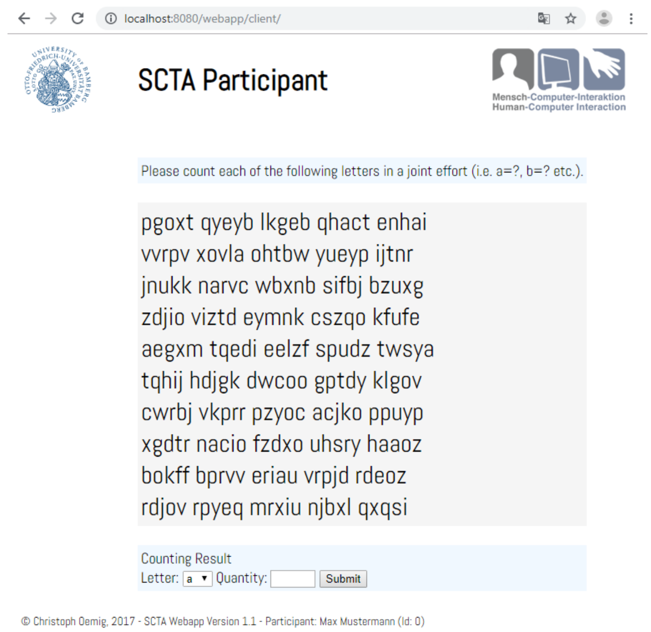


**Figure 1: Screen showing the primary counting task.**

The entire procedure follows the general assumption that if people know something properly, they can answer questions about it quickly and correctly. Therefore, response times and correctness are recorded along with the answers to each query. Since the original counting results also record who actually counted the letter, the list of answers returned by the participants can also be analysed in terms of self and group awareness. The number and timing of freeze probes can be configured freely. The results can be displayed directly as bar charts inside the SCTA tool or exported as comma-separated values (CSV) to be analysed in an external application.

## 3 Experiment

This section provides a brief overview of the experiment's setup and results.

### 3.1 Participants

We invited 8 participants (age 29 to 47, 6 males, 2 females) to engage in the counting task in pairs. They provided their consent to participate in the study and to the publication of its results.

### 3.2 Design

In terms of variables we used four types of interruptions as independent variable and observed their effect on the secondary task knowledge (dependent variable). The four types are based on the two dimensions of duration and interference:

- Scenario 1 uses a short interruption with no interfering content (i.e., content not related to another counting task).
- Scenario 2 draws again on a short interruption but this time with interfering content.
- Scenario 3 introduces a long interruption with no interfering content, while
- Scenario 4 again uses interfering content in combination with a longer interruption.

### 3.3 Procedure

The participants were collocated in one room and were allowed to take notes and to share their results verbally, but neither their screens nor notes. The overall duration of one experiment was limited to four minutes counting time (plus the time required by the freeze probes and interruption that varied in length). The text to be analysed covered 250 characters (cf. Figure 1). We configured three freeze probes: one before the interruption to capture the pre-interruption state, one after the interruption to capture the post-interruptions state and one shortly before the end of the task to learn about the recovery state of the interrupted participant (cf. Figure 2). Each run of the experiment started with a briefing, followed by the counting task which was concluded by a short interview of the participants, asking them how they experienced the task. A short debriefing finalized the experiment.

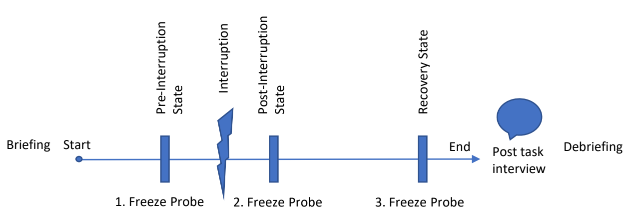


**Figure 2: Experiment setup.**

For each counting task (also called run) two participants were chosen randomly. The small sample size required participants to take part in multiple runs, yet, always with a new counting task. To learn more on interruptions and their impact on secondary task knowledge, we decided to assign the chosen couple to one out of the four aforementioned scenarios. In total we used four measurements per scenario (i.e., 16 measurements in total). Interruptions were mimicked as phone calls. Short interruptions only contained a single question. In case of interfering content, it asked a question like "How many Ts contains the name Tottenham Hotspurs?". In case of non-interfering content, it asked for the weekday or some personal information. Long interruptions were made up of 10 questions like the single ones above depending on the need to be interfering or not. Only one participant is interrupted, the other is explicitly allowed to continue counting or to stand-by and wait. Following the interruption participants were required to synchronize upon the interrupted participant's return to the task. The focus of the measurements in this experiment is on the interrupted person. As part of the experiment participants were also observed especially in the recovery phase which followed the post-interruption freeze probe (cf. Figure 2) in order to gain some insights on how people restore their secondary task knowledge.

### 3.4 Results & Discussion

As to be expected all scenarios showed a similar pattern in the pre-interruption state with equally high levels in terms of speed and correctness regarding the answers to the questions asked during the freeze probes. The most significant changes can be found in the post-interruption state and recovery state. The largest impact could be found with the long interruption with interfering content. The interruption also appeared to impact the speed more than the correctness for each scenario. As all experiments had the same length, the impact was also visible in the recovery state. Obviously, participants needed more time to recover from long and interfering disruptions than from shorter and non-interfering ones. The results are depicted in Figure 3.

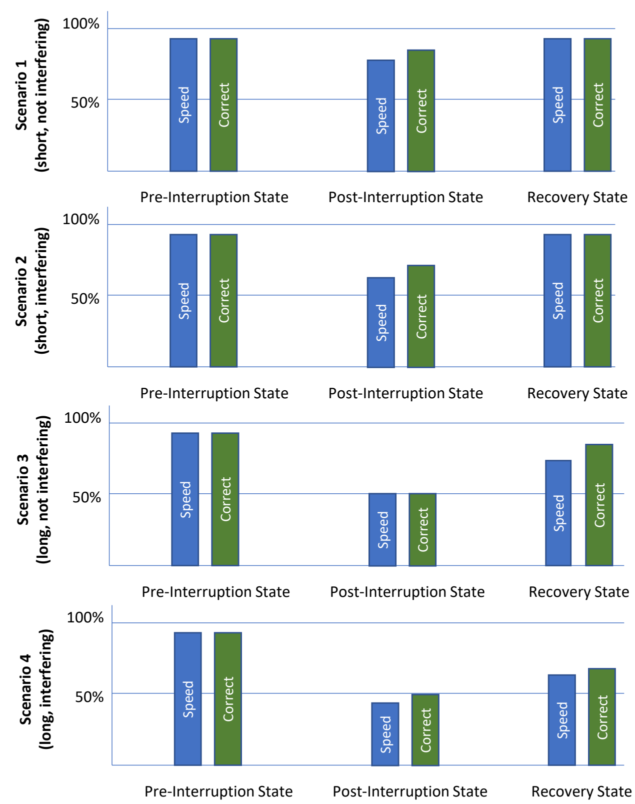


**Figure 3: Results for the four scenarios.**

The impact on speed rather than correctness is possibly due to participants having to think longer but eventually recalling the correct answer, suggesting a greater effort to do so. The increased timespan needed to recover from long and interfering disruptions can be explained by the observations during the experiment's recovery phase where we found two types: quick and long recovery modes. Participants shifted their recovery mode especially after long and interfering interruptions. While they used a little thinking by themselves ("Ok, just a second, where was I.") for short interruptions in the quick recovery mode, they actively engaged their companion to help them recover ("Can you help me out, what did you count?") for the long recovery mode.

Another significant observation during the recovery phase was that though the non-interrupted participants were told to be free to choose whether to stand-by or to continue counting, nearly all of them chose the stand-by mode, i.e., they waited for their partner to return to the task. Being asked for the reason revealed the social nuance that they did not know how long the interruption would last and that they did not feel comfortable in leaving their fellow participant behind. In this case individual preferences clearly overrode a team's performance (a finding also described by Nielsen [8] in his work on the correlation of efficiency, effectiveness and satisfaction in usability evaluations and also found in a slightly different form in one of our earlier experiments on awareness and coordination support [10]).

Overall and under the given circumstances (small sample size, work-in-progress to get a first indication) we just present the descriptive statistics. Future work could include a larger sample size and systematically analyse the variances within and between the different scenarios.

## 4 Conclusions & Outlook

In this paper we reported briefly on the findings of a simple experiment observing the impacts of four interruptions types (short-non-interfering, short-interfering, long-non-interfering, and long interfering) on secondary task knowledge with a special focus on the participant recovering from the disruption. While the long-interfering interruption was the one with the greatest impact (measured in terms of speed and correctness of the answers to the questions regarding the secondary task knowledge), we also discovered two modes of recovery (quick and long) depending on the type of interruption as well. Additionally, we also found the social nuance that participants sacrifice the team's overall performance to wait for their interrupted counterpart rather than to continue with the task at hand. Though being work in progress the result appears to be sufficiently interesting to be shared requiring larger samples to verify the results.

On the other end there was the initial suspicion that the applied freeze probes themselves might be perceived as interruptions. However, they did not turn out to be a serious confounding variable. They were perceived by the participants as short interruptions without any interference since they dealt with the knowledge of the same task. A possible experiment that could expand on this issue could include the chaining of multiple freeze probes thus checking their influence on one another. Here, the confounding effects appear to be smaller than those of the interruption in Scenario 1.

Next steps after this experiment could include some variations of this experiment: they could use a longer task with more letters and more participants. Variations could also be created by introducing even longer interruptions or in placing the interruption not only near the beginning but also more to the middle or end of the task, again observing the effects on the recovery activities. Another option could be to study the effects of multiple interruptions, especially ones disrupting the recovery phase. Finally, other experiments could focus on the participants not being interrupted directly observing their activities during their time waiting for their partner to return. As part of an adaptive coordination support system they would need to be supported differently than their interrupted counterpart.

## ACKNOWLEDGEMENTS

We like to thank all people participating in the experiment, and all reviewers for their valuable comments and suggestions on earlier versions of this work.

## REFERENCES

[1] Joseph B Bayer, Nicole B Ellison, Sarita Y Schoenebeck, and Emily B Falk. 2016. Sharing the Small Moments: Ephemeral Social Interaction on Snapchat. *Information, Commun. Soc.* 19, 7 (2016), 956–977.

[2] Jun Chen, Chaokun Wang, and Jianmin Wang. 2014. Modeling the Interest-Forgetting Curve for Music Recommendation. In *Proceedings of the 22Nd ACM International Conference on Multimedia* (MM '14), 921–924. DOI:https://doi.org/10.1145/2647868.2654954

[3] Edward Cutrell, Mary Czerwinski, and Eric Horvitz. 2001. Notification, Disruption, and Memory: Effects of Messaging Interruptions on Memory and Performance. In *Conference on Human-Computer Interaction Interact 2001*, 263–269.

[4] Hermann Ebbinghaus. 1885. Memory: A Contribution to Experimental Psychology. *Mem. A Contrib. to Exp. Psychol.* 15, (1885), 1–7. DOI:https://doi.org/52, 281-302

[5] R. Endsley, Mica. 1995. Measurement of Situation Awareness in Dynamic Systems. *Hum. Factors* 37, 1 (1995), 65–84.

[6] Tom Gross. 2013. Supporting Effortless Coordination: 25 Years of Awareness Research. *Comput. Support. Coop. Work* 22, 4–6 (August 2013), 425–474. DOI:https://doi.org/10.1007/s10606-013-9190-x

[7] Gloria Mark, Daniela Gudith, and Ulrich Klocke. 2008. The Cost of Interrupted Work: More Speed and Stress. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08), 107–110. DOI:https://doi.org/10.1145/1357054.1357072

[8] Jakob Nielsen and Jonathan Levy. 1994. Measuring usability: preference vs. performance. *Commun. ACM* 37, 4 (April 1994), 66–75. DOI:https://doi.org/10.1145/175276.175282

[9] Christoph Oemig and Tom Gross. 2011. Illusive, Ineffective, Inefficient, Ideal: Standardized Coordination Task Assessments of Awareness Support. In *Mensch & Computer 2011: überMEDIENÜBERmorgen - 11. fachübergreifende Konferenz für interaktive und kooperative Medien, Chemnitz, Germany, September 11-14, 2011*, 353–356. Retrieved from http://dl.mensch-und-computer.de/handle/123456789/1535

[10] Christoph Oemig and Tom Gross. 2014. The Awareness-/Coordination-Support-System Paradox. In *Mensch & Computer 2014 - Tagungsband, 14. Fachübergreifende Konferenz für Interaktive und Kooperative Medien - Interaktiv unterwegs - Freiräume gestalten, 31. August - 3. September 2014, München, Germanyaktive und Kooperative Medien - Interaktiv unterünch*, 125–134. Retrieved from http://dl.mensch-und-computer.de/handle/123456789/3822