Coagmento v3.0: Rapid Prototyping of Web Search Experiments

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ABSTRACT

As understanding of web search behavior grows, researchers rapidly develop new study designs to capture and understand search behavior. Researchers have restricted time in which to design a study, develop a collection tool, collect data, analyze it, and report new insights. In particular, sufficient time and development skills are often required to create a tool that meets the needs of any particular web search behavior study. Coagmento is a tool that is developed for facilitating many of the needs for designing and running a lab study, from executing a session flow to collecting log data. By streamlining the programming of unique parts for a specific study, Coagmento helps researchers tailor various parts of running a user study, lowering the barrier for designing and conducting lab study experiments. One-click interactions with a graphical user interface permit researchers to operate through a web-based administrative service to generate stages, search tasks, and questionnaires for their interactive information retrieval studies. In this demonstration, Coagmento provides a solution to increase efficiency in the production of laboratory experiments for web search behavior.

CCS CONCEPTS

• **Information systems** → **Task models**; *Search interfaces*; Test collections; • **Human-centered computing** → *Open source software*;

KEYWORDS

collaborative information seeking, human-computer interaction, information retrieval, user studies, task-model studies, web search behavior

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1 BACKGROUND

Interactive Information Retrieval (IIR) - as a research discipline - broadly refers to research studying people's search behaviors in electronic environments to determine predictable or distinguishable patterns between behaviors, different types of users, and/or the tasks that drive users' searches. IIR researchers define the environmental or user characteristics they wish to study, for instance a search task's complexity [3] or the time constraint experienced by a user when searching [6]. Researchers manipulate that independent variable and observe how these changes affect behaviors. Researchers in IIR have studied diverse aspects of the user or task context. Researchers have studied changes in behavior for general web searching [5, 24] and also domain-specific searches [18, 25]. They have also studied constructs such as general topic familiarity [14], users' engagement with a task [7], and even search task determinability [4], among others.

Despite this diversity in research agendas, the necessary mechanisms to support such studies share several commonalities. For one, the studies often passively collect the searching behavior of participants - for instance, their clicks on links, queries issued to search engines, and time spent on content pages [3, 4, 17]. They also often explicitly collect questionnaire information from their users, tailored to the specific design of their study. Such questions may elicit information about general demographics [28] or about their field of expertise [22] or their general search expertise. Researchers may also ask participants before they begin searching about their general familiarity with the topic [14]. After the task, researchers may ask participants about the difficulties searchers faced [17], about how engaged they were with the task [7], or even about their intentions for a specific query [19].

When a researcher has a new research question, she carefully designs components of her respective study. She determines how much passive data to collect, what questionnaires to create, what tasks should be assigned to searchers, the order in which tasks should be presented, and the logical flow of these items from start to finish. This conceptual design is a given overhead cost for any new study. Generally, the flow from research question to research product proceeds as follows: determining the research questions, designing the study, developing a data collection tool, collecting data, analyzing it, and reporting new insights. Substantial overhead exists in developing the collection tool, yet despite the diversity in studies, IIR studies follow similar patterns. Figure 1 represents a common workflow for participants in IIR studies, followed by past and recent research efforts [7, 13, 19]. Study participants often engage in a linear flow of stages. Stages may contain questionnaires and/or a prompt of the participant's designated search task. There is currently no tool that acknowledges these common study design patterns and leverages this insight to expedite the process of creating a study. Coagmento serves as an appropriate solution in this regard. Once a study has been designed, Coagmento allows

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researchers to quickly create and manipulate these common constructs of IIR studies through a graphical user interface, expediting the creation of a novel study. This saves a considerable amount of time with easy access for study creation, consequently allowing researchers to focus less attention on programming the study and more attention on design and analysis. Particularly, this system is useful for researchers beginning research in IIR as well as managing portions of the development that requires substantial effort otherwise. In this paper, we will present a version of Coagmento that helps support this prototyping, additionally discussing its implications for future research in IIR.

2 WHAT IS COAGMENTO?

2.1 Coagmento in the Past

Coagmento originally debuted in 2008 as a tool to collect data for collaborative information seeking. It followed the work of pre-existing tools to support collaborative information seeking such as Ariadne [27], Cerchiamo [8], CoSearch [2], and SearchTogether [23]. Subsequent versions since 2008 have been demonstrated at various venues (e.g., [10, 21]). Coagmento has been used in several versions and in several studies to passively collect searching and browsing behaviors like described above. For instance, Hendahewa and Shah [12] examined users in a traditional lab setting to predict from behavior how well a person will perform in the future in a session-based Web search task. González-Ibáñez et al. [9] used Coagmento to examine the relationship between mood and information seeking behaviors. Knight et al. [15] deployed it in a larger scale laboratory study of over 1,000 users to study searchers' assessments of expertise and document trust. Mitsui et al. [19] used it to compare searchers' observed behaviors to the information seeking intentions they reported for a given moment. Most versions focused on collecting information related to user search behavior on the general web and specialized web-based portals such as digital libraries (e.g., [26]). As of recently, researchers using Coagmento were required to modify its source code as per their study design [21].

In light of the needs specified in the Introduction, the newest version of Coagmento - presented here - facilitates the prototyping of a working web search behavior study and data collection tool with little programming intervention. First, this workflow allows for a rapid prototyping of user studies. Since several IIR studies follow similar templates, creating similar studies should require minimal effort. Second, a interface-based approach to creating a study lowers the learning curve to create one. Researchers who are generally interested in IIR but have little programming experience have a more accessible method for realizing their research agendas. Through a graphical user interface (GUI), Coagmento allows researchers to operate and manage a web-based administrative service to generate web-search studies. Our work aims to allow researchers to explore their research in a time-effective and cost-effective manner.

2.2 Administrative Tools

Coagmento is a web-based application that allows for users to set up their own custom studies with minimal programming. Given that a researcher has already designed a new IIR study on paper, Coagmento facilitates the management of task design, participant workflow design, questionnaire creation, participant registration, and communication with participants. In particular, it offers a GUI-based administration tool with the following support, to help create web search behavior studies.

2.2.1 Task Representation. One central unit of analysis in IIR studies is the *task*. It is believed that tasks vary along several important measurable characteristics - such as the topic, task type, and task complexity - that influence behavior. Tasks may vary categorically - e.g., having a "well-defined" or "ill-defined" goal [16] - or even numerically - being increasingly or decreasingly complex. Coagmento allows administrators to first create the task prompt that will be shown to study participants (e.g., "You are a student in an undergraduate history course. Please bookmark 5 pages on World War II."). Administrators can further define how these tasks should be characterized. Administrators are not limited to varying tasks' goal or complexity but may define new categories, such as the task's determinability, the task product, or the topic, to fit the needs of a study. A task presented to a participant may subsequently be characterized by multiple attributes simultaneously (e.g., specific goal + factual product + medium complexity).

2.2.2 Task Assignment by Rotation. Not every user should be exposed to identical tasks in identical order. More generally, it is often desired to expose different participants to different conditions to determine the effect of that condition (as independent variable) on search and browsing behaviors (as dependent variables). A Coagmento administrator can specifically determine which task each participant is exposed to. If study participants are only required to search on one task, the task that participant is exposed to can be manipulated. If a single participant must search on multiple tasks sequentially, the order of these tasks can also be altered per participant to reduce ordering effects.

This is performed by designating participants to a row in an assignment table, with each row specifying the configuration for a study participant. Such a table can be manually created by the user. We also provide a Latin square algorithm [1] to automatically generate such a table. Given a number of columns n, the algorithm generates and rearranges a $n \times n$ table to equally expose each participant to different conditions. This is a common method to counteract ordering effects such as participant fatigue or learning effects [11]. The user may opt to use the provided algorithm or add, remove, or reorder rows in the participant assignment table as needed (or do both in parallel).

2.2.3 Questionnaires. Often, qualitative self-reported data is collected from participants during the course of IIR or web search studies. It is elicited from basic demographic questionnaires, questionnaires about a participant's search expertise or domain expertise [17], and pre-task and post-task questionnaires about anticipated or experienced task difficulty or topic familiarity, respectively. Coagmento provides a dedicated tool for creating questionnaires. It supports a variety of common question types: Likert scale, multiple choice, numerical, and open-ended text. It provides configuration options per question, such as optional help text, validation options, and text formatting. Administrators may create, edit, and save questionnaires for later reuse. Questionnaires and their respective answers are loaded and saved to Coagmento's MySQL database.

Figure 1: An example study setup which includes a demographic questionnaire, task, and pretask/posttask questionnaires; this linear flow of stages can be easily replicated by Coagmento.

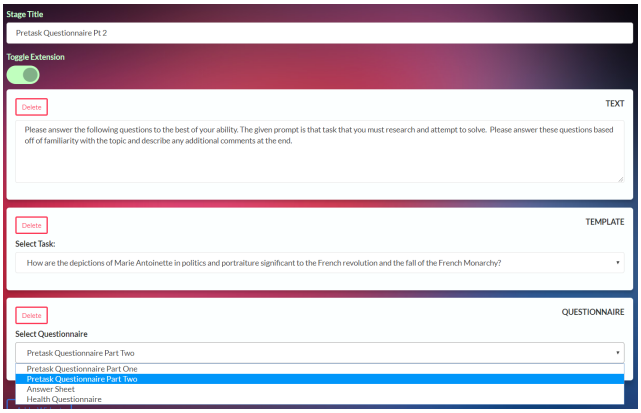

Figure 2: Example stage editor. Each section represents a component of the stage. Components are draggable for rearrangement. A previewing exists to examine the participant's point of view of the stage.

Rendering questionnaires - both for editing and displaying to participants - is supported through formBuilder[1], an external JavaScript library. The support provided by Coagmento and formBuilder allows for easy and efficient questionnaire creation, removal, and editing.

Questionnaires are not tied to any particular stage of the study. Some questionnaires should be asked per user (e.g., demographics), and some should be asked for each task a user conducts (e.g., task difficulty). As explained next, the placement of each questionnaire can be controlled by the user. This similarly applies to visible components of the study, as each visible component in the study is treated as a "widget".

2.2.4 Stages. Figure 1 demonstrates one common type of study flow. A participant logs into Coagmento and is welcomed by the system, answers a demographic questionnaire, engages with pretask materials, conducts the search task provided by the researchers, engages with posttask materials, and concludes participation in the study. This is one basic flow, and some modifications to this design are also common. Participants may engage in multiple series of pretask-task-posttask episodes. Alternatively, they may engage in several Google-a-day tasks before concluding with one general postsearch questionnaire. Coagmento has the ability to support all of these linear stage flows and more. And again, it can support these quite effortlessly through the GUI. Generally speaking, each can be composed of one or more of the following components:

- Static text - e.g., "Welcome..."
- Task prompt - e.g., "You are enrolled in a Japanese history course... Please bookmark 5 pages on..."
- Questionnaire - e.g., demographic questionnaire or posttask questionnaire
- Resource files - e.g., a training video/PDF

Each of these is a potential "widget" in a stage. A welcome stage may only include static text, while a demographic questionnaire stage may omit any task prompts or resource files. If a stage requires a questionnaire or a task, the creator references a previously created item. Figure 2 shows an administrator creating a task stage, additionally selecting the previously made "Pretask Questionnaire Part One". Lastly, administrators can rapidly edit and reorder stages in a drag-and-drop fashion. They may also toggle whether the Chrome extension should actively record search behavior. Admins can also preview a stage as it would be presented to a study participant.

2.2.5 User Management. Coagmento administrators can control login permissions of users. Participants by default cannot log in unless granted access, preventing premature login until the participant meets a requirement - such as meeting the administrator face-to-face before conducting the study. Upon first login, participants are designated to one of the task rotations described above. Coagmento also provides a method for creating e-mail templates to communicate with participants. For instance, one template may be introductory instructions for navigating to the physical laboratory to conduct the study or to provide instructions on payment collection. In Coagmento's current state, researchers must manually send out these e-mail to participants.

A fresh installation of Coagmento has a default administrative user with default credentials that can be modified. Multiple administrative accounts can be created so that collaborating researchers can create components of the study. For debugging purposes, a Coagmento user may also create user accounts with random user names and credentials.

2.2.6 Chrome Extension Interface. Coagmento is additionally comprised of a Chrome extension that collects information pertaining to a participant's web interactions, such as querying to search engines, clicking results, and spending time on pages. The browser plug-in includes a Chrome menu button with popup menu and a right-click context menu for saving bookmarks and page text snippets [20].

[1]https://formbuilder.readthedocs.io/en/latest/

2.2.7 Setup. Coagmento's backend primarily comprises of PHP, built on Laravel [2] to create a RESTful framework. If programming is required, Laravel's standard structure is highly supported by online tutorials. The front-end is largely custom HTML, CSS, and JavaScript, and the Chrome Extension is also custom. While these help support the rendering of a specific study, most other components of the study are otherwise not hard coded. Task stage layout, stage order, task prompts, questionnaires, and answers are manipulated, saved, and retrieved as records to and from a MySQL database. Out of the box, configuration of the database is largely handled in advance, with the final setup only requiring a single command ('php artisan migrate'). Coagmento can be run locally on a laptop but is intended to run on a remote server so that participants may access it via the web.

3 CONCLUSION

Coagmento provides a platform for IIR researchers to rapidly prototype a study with a button-guided interface. Coagmento provides a plethora of tools to create a tailored research design and collect searcher data. Creation of questionnaires, tasks, and stages can all be done on Coagmento's GUI. Some features can be enabled or disabled according to the design specification. While the above demonstration largely advocated for Coagmento's support for laboratory-based studies, it can in theory be applied to naturalistic settings where participants remotely install Coagmento on their personal computers, and it has been applied accordingly in practice. In short, Coagmento can help rapidly create old and new study designs, expediting the research pipeline in the field of IIR.

For the current suite of features described, Coagmento requires no programming interventions to create a customized web search behavior study. Installation of Coagmento is required on the server where data will be stored, and installation of the Chrome extension is required on study participants' machines (or a laboratory machine). Configuring Coagmento for one's study largely requires manipulations through 1) configuration files or 2) the graphical user interface. In a few cases, the Coagmento code base may require programmer intervention. This is necessary if a researcher wants to develop a novel Chrome extension data collection tool - e.g., if the researcher wants to clean and collect Quora or Spotify API calls or wants to embed an external recommender system into the extension.

In Coagmento's current form, the code base only supports the creation of a single study. A researcher who wants to run multiple studies will need to copy multiple instances of the code base and reconfigure one for each study instance. An extension to the work presented here is to treat each study as an object and to design Coagmento as a factory that can create, moderate, and run studies simultaneously. On a related note, a small future extension to Coagmento is a suite of visualizations to monitor the progress of the completion of a study (e.g., # of completed users and # open registrations). Lastly, while Coagmento currently supports only the designed rotation of tasks (viz., Latin square) between participants, it should eventually support the rotation of other components as well, such as the rotation of questions within a questionnaire and the configuration of other environmental factors, such as controlling whether there is a time constraint as in previous studies [6].

Future work on Coagmento includes the implementation of data collection from external devices such as Electroencephalogram (EEG), eye tracking, and mobile devices. These have become popular methods of data collection for recent research in IIR. Coagmento should allow researchers to toggle whether (and which) physiological data collection tools are being used, as well as whether the participant is using a mobile or desktop/laptop device. At minimum, it should support the most commonly used models and operating systems. Another future direction is to manage interactions with common test collections and common non-commercial IR engines. IIR researchers often use standard non-commercial search engines such as Indri[3] or Terrier[4] and create search indexes on available domain-specific or general Web document corpora. One last feature is to manage more of the data itself through the GUI.

4 WHAT'S IN THE DEMONSTRATION?

In this demonstration, we will present the front-end administrative functionality of Coagmento. We will show conference participants how to create a basic study flow such as the one in Figure 1, demonstrating how to create tasks, questionnaires, and stages in the proper order, as well as how to register and run participants. We will also assist interested individuals with installing Coagmento locally on their machines to test the system independently. Additionally, we will present and describe basic portions of the code base to individuals interested in replicating, recreating, or extending Coagmento. The code is available for open source on GitHub[5].

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