**Recognition Memory Experiment Framework**
**Software Requirements**

University of Victoria

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# Overview

The objective is to create a framework for parametric generation of Recognition Memory experiments, to support researchers at the University of Victoria. The software is web based and intended to be self contained, yet comprehensive and reasonably flexible.

**Guiding principle**: The software is to be structured to facilitate creating new versions of recognition memory studies with a substantial array of stimuli, response, and instruction possibilities.

## A. General Requirements

The software is to be web-based and generally organized into an inward facing portion and an outward facing portion. The inward facing portion, available to researchers, represents the interface for generating studies. The researcher may construct a survey by sequentially arranging the various available survey element possibilities. The outward facing portion is comprised of the resulting survey pages that are made available to experiment participants.

1. The inward and outward facing software should interact properly with a user of a current desktop implementation of a web browser.
    a. Firefox, Chrome, and "Internet Explorer" browsers should be supported.
2. The outward facing program consists of web page(s) that are ready to be used with Amazon's Mechanical Turk platform.
    a. It should be possible to administer the survey by pasting a survey-link into the Mechanical Turk hit-manager interface, for administering delivery to Mechanical Turk's workers.
    b. Typically Mechanical Turk provides a user identification number. This should be retrieved and included in the software's data output stream.

   c. The developer will test the above with Mechanical Turk's sandbox.
   d. API-level interaction with Mechanical Turk need not be addressed in this implementation; however we note that this could be addressed in a future specification, since API-level interaction would be required to manage special payoff incentives administered to encourage certain types of participant behavior.
      i. An example of this type of involvement is available in terms of an experiment based on conjoining the *psiTurk* (psiTurk: An open platform for science on Amazon Mechanical Turk) and *jsPsych* (jsPsych Documentation) packages.
3. The outward facing web page(s) are generally available at a location determined by a randomly generated code that we provide to participants.
   a. The outward facing site is otherwise hidden.
4. The data stream resulting from participant interactions is to be stored on the web-server, in CSV format convenient for processing in "The R-project for Statistical Computing" or "MS Excel" software.
   a. The data are to be recorded comprehensively enough to simulate the participant's experience, including keyboard responses, in terms of key-press events.
   b. An archive of the data stream should be downloadable by pressing a button on the inward-facing site.
   c. Times recorded as part of the data stream representing response latencies, input parameters, or otherwise, should be recorded in milliseconds (mS).
   d. Full documentation to be provided for source code and programs.
5. The software should primarily reside at UVic's web server.
   a. The investigator portion of the site to be accessible by login or private key-phrase available only to the principal researchers.
6. Software should be made available to the community on GitHub.
7. If development time remains after development of primary features, this time could be spent to increase user-friendliness of the inward-facing site, e.g., by updating the sequencing modality to a drag-and-drop format.
8. The inward facing investigator portion of the site, and the outward facing survey content of the site, should both reflect the principles of an experiment as a composite of subunits of the types of tasks listed in the section: "Functional Requirements".

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## B) Functional Requirements

All components of an interactive psychological survey corresponding to a Recognition Memory experiment, whether represented in the inward facing or outward facing software, are modeled in terms of "events". We deem that an "event" is composed of one or more "interactions" or groups of "interactions". An "interaction" (like an individual "slide" from MS PowerPoint) is the most basic element of the interactive survey and cannot be further decomposed into any simpler elements. The four (really there are only three) possibilities for "interactions" (which we will interchangeably refer to as "slides") are determined by a) whether we have enabled the Stimulus Exposure Time (SET) and b) whether we have enabled expiry of the "slide" in response to acceptable key-presses, as in Fig. 1:

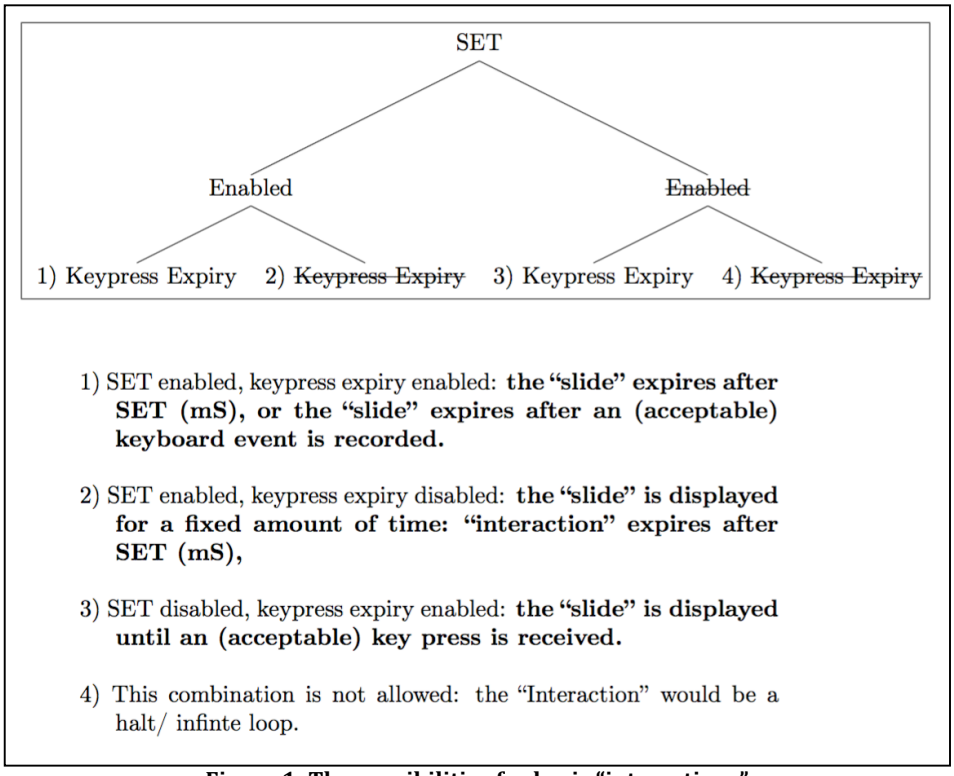


**Figure 1: The possibilities for basic "interactions"**

1. Events are defined to be composites of one or more "interaction"(s) and, necessarily, events have a beginning and an end.
    a. Where applicable, start and end times are recorded.
    b. Timings are to be reported in milliseconds (mS).
    c. The overall events pertinent to this study may be described hierarchically in three levels:

i. Experiment (the overall interactive survey)
ii. Task (an experiment is made up of different types of tasks)
iii. Trial (each task may include multiple trials; each "Trial" is comprised by one or more "interaction"(s)).

d. We need not explicitly represent the entire experiment as an "Event". Clearly the overall end time is the largest of the end times recorded.
e. A "Trial" (or "Subtask") is a group of basic "Interactions", where:
   i. "Trial"(s) are performed repeatedly, a specified # of times.
   ii. A group of repeated "Trial"(s), of which there are a specified number, comprises a "Task".
f. An "Interaction" is an atomic "Event": the simplest possible building block of an interactive survey.
   i. An "Interaction" has a start time recorded at the point it is invoked by the system.
   ii. An "Interaction" may persist until a predetermined time limit is reached (SET) or, alternatively, may end on receipt of keyboard input, according to the possibilities in Fig. 1.
   iii. Generally speaking, an "Interaction" consists of a temporarily fixed state of a "Stimulus" being presented on the computer screen (while listening for participant keyboard events) where the "Stimulus" may be composed of:
      1. Words, images, a video file, and/or text, or Nothing
   iv. For an "Interaction", which we can think of as being like a single "slide" in an MS PowerPoint presentation, the above presentation occurs for a fixed amount of time, or, where applicable, the "Interaction" may be terminated early on receipt of keyboard events (key presses) from the user.
      1. The parameter SET (Stimulus Exposure Time) in milliseconds (mS), when enabled, limits the duration for which an "interaction" exposes its stimulus (if any).
      2. An "interaction" has a second parameter that, when set to true, enables termination of the interaction, upon receipt of certain specified "admissible" key-presses.
g. The general types of "Tasks" deemed to be available for composing interactive survey, and for which this specification is responsible are enumerated as the remaining items in the list (items 2., 3., 4., and 5., respectively) which we briefly summarize here:
   i. Instructions Task
   ii. Response Task
   iii. Delay Task
   iv. Stimulus-related Task (Orientation Task, or Recognition Memory test)

h. Generally, the inward facing site presents the researcher with options for creating and modifying sequences of tasks.
    i. For each task, the researcher will specify parameter values including numerical values, text content, image files, or other specified data.
i. Before proceeding to listing the types of "Tasks", we note there are two subtypes of "Stimulus-related Task", as follows:
    i. Orientation Task
    ii. Recognition Task
j. An "Orientation Task" involves the presentation of a series of "Stimuli", (e.g., images or words) without necessarily requiring (but allow for the possibility of) a response by the participants
    i. For the "Orientation Task", a "Trial" is defined to include the presentation of an individual "Stimulus", as part of a series of "Stimuli".
    ii. Each "Trial" may also include an inter-stimulus "interval" (i.e., a blank screen for a given duration).
    iii. Responses by the participant (multiple choice question/response) may also be included for each "Trial".
        1. A ratio or frequency can be set so that extra feedback opportunities are included on only a fraction of trials.
k. A "Recognition Task" similarly involves the presentation of a series of "Stimuli".
    i. A "Recognition Task" differs from an "Orientation Task" in that feedback from the participant is required for each "Trial". Particularly, each "Trial" includes an interaction that presents a stimulus, where key-press information is expected.
    ii. We will require an "Orientation Task" precede a "Recognition Task", because the set of "Stimuli" upon which the "Recognition Task" are based is a superset of the set of "Stimuli" upon the corresponding "Orientation Task".
    iii. That is, the "Recognition Task" involves presentation of a group of "Stimuli", some of which were already presented in the preceding "Orientation Task".
    iv. For the "Recognition Task", the researcher has the option for the participant to judge whether or not a given image was already presented.
    v. As is the case for the "Orientation Task", for the "Recognition Task", in general: responses (multiple choice question/response) may be included for each "Trial".

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2. Instructions Task
    a. An "Instructions Task" is the simplest kind of "Task", consisting of the most trivial kind of "Interaction" possible:
        i. An "Instructions Task" displays selected text data simply, as on an individual PowerPoint "slide" with no special formatting.
        ii. We shall assume that an "Instructions Task" lasts until a key is pressed. In this case the list of "admissible keys" is all-inclusive.
        iii. The software could automatically include an instruction for the participant to press the Space Bar (if desired).
        iv. According to the above, the researcher must be able to select, upload and/or modify text, to be used at a specified point within a survey, for purposes including but not limited to: presentation of instructions or informed consent text.
3. Response Task
    a. A "Response Task" consists of a series of "Trials"
    b. Each "Trial" for the "Response Task" consists of one question, for which the researcher is able to set the text (and possible participant responses). The format of the reply is specified as limited to one of the following possibilities:
        i. Open (a text box is provided for input).
        ii. Yes/no (the participant is instructed to press Y or N).
        iii. Rating (the participant is instructed to press a number from 1 to 5).
        iv. Multiple Choice (the participant is instructed to press a key such as one of the keys {a, b, c, d}, as appropriate, given the response possibilities indicated by the researcher.
4. Delay Task
    a. A "Delay Task" consists of at least one (but possibly more) of the following possibilities:
        i. A mental rotation task cf. the *Qualtrics* survey software platform.
        ii. Asking the participant to list as many countries as possible during a 3-minute period.
        iii. Asking the participant to follow a moving ball, bouncing against the perimeter of the screen, with their eyes.
        iv. Watching a brief video.
    b. We shall assume that the "country listing" option is the primary option requiring implementation.
5. Stimulus-related Task
    a. For each subject and for each execution of an interactive survey the set of items to be studied is required to be selected and ordered

randomly, both for the "Orientation Task" and "Recognition Task" (the latter implementing the actual recognition memory experiment).

b. Again, the set of "Stimuli" for a "Recognition Task" subsumes that of the set of "Stimuli" for the associated "Orientation Task", and the set of "Stimuli" for the "Recognition Task" includes additional "Stimuli" above and beyond those "Stimuli" presented in the associated "Orientation Task". All selections used in Stimulus related tasks are given a new random ordering.
c. A "Stimulus-related Task" requires specification of one or more "Stimuli Pool"(s), as follows.
    i. A "Stimuli Pool" is a labeled (numerically indexed) group of samples (words and/or images, or both) that the researcher must be allowed to specify.
    ii. Thus, the series of "Stimuli" exhibited in an "Orientation Task" or "Recognition Task" needs to be associated with one or more researcher-specified "Stimuli" categories (the "Stimuli pools"), where each "Stimuli pool" has associated to it a label, allowing the originating categories of "Stimuli" to be tracked.
    iii. One or more "Stimuli Pools" are supplied by the researcher as parameters for an "Orientation Task". Samples are then drawn pseudo-randomly from among the pools.
    iv. Because we assume that a "Recognition Task" generally is subsequent to an "Orientation Task", the "Orientation Task" with which a "Recognition Task" is associated, is to be listed among the parameters of that "Recognition Task".
    v. One or more "Stimuli Pools" are not expressed as parameters for a "Recognition Task", since the "Stimuli Pools" used in the "Recognition Task" are identical to those used in the associated "Orientation Task".
    vi. For the "Stimulus-related Task", we do not explicitly specify the type of "Stimulus", since the types of "Stimuli" used are variable, and are effectively determined by the specification of one or more "Stimuli Pool"(s).
    vii. A "Stimuli Pool" may contain both images and words, or possibly other data.
    viii. Thus word and image data may be randomly intermixed for the "Orientation Task" and the "Recognition Task".
    ix. Word data are to be entered by the researcher in one of the following formats:
        1. Comma Separated
        2. Space Separated
        3. Line Separated

d. For the "Orientation Task" the researcher supplies a parameter ("N"): this represents the size of a sample (to be pseudo-randomly selected) from the associated "Stimuli Pool"(s).
    i. Because a "Recognition Task" is associated with an "Orientation Task", for a "Recognition Task" the parameter "N" is predestined.
    ii. A parameter N and a parameter M will be implemented, one of each, for each "Stimuli Pool".
e. For the "Recognition Task", the researcher needs to specify an additional parameter ("M"), which represents the size of an additional sample that is to be drawn from the same input "Stimuli Pool"(s).
    i. The additional sample of "Stimuli", of size "M", is to be pseudo-randomly combined (by "shuffling") together with the same sample of "Stimuli" already presented in the associated "Orientation Task".
f. Each "Stimulus-related Task" involves a number of trials.
    i. An "Orientation Task" has "N" trials (where "N" is the parameter mentioned before).
    ii. A "Recognition Task" has N+M trials (where "N" and "M" are the parameters mentioned before).
g. The data stream for a "Stimulus-related Task" consists of a group of entries: according to the above principles, there is one group of entries for each "Trial" ("Sub-Task"). The data stream for other kinds of tasks is defined analogously. The data entries recorded for one "Trial" of a "Stimulus-related Task" include:
    i. A *task number/index* (representing the order of the "Task" in terms of its place in the sequence of "Tasks" as part of the overall experiment. Technically, this is assigned to the "Task", but we can consider this property to extend to each of the "Trials" within the "Task".
    ii. A *trial number/index* (representing the order of the "Trial" in terms of its position in sequence within the "Task". This property is inherent to the "Trial" itself.
    iii. The *duration* of the "Trial", which is recorded separately and/or is calculated as the difference between the maximum time that is recorded during the "Trial", less the minimum time recorded during the "Trial".
    iv. A *response time*, if the "Trial" was terminated by participant keyboard event (this is applicable if the "Trial" belongs to a "Task" which allows a constituent "Trial" to be terminated "early" by participant keyboard input.

v. An *Inter-Stimulus Interval* (ISI) or *latency*—if a non-zero *latency* is specified for the "Task" (latency is an inherent property of "Stimulus-related Task", which each "Trial" for this type of "Task" inherits, since "Task" is the ontological ancestor for a "Trial") then, the "Trial" is composed of at least two temporally-composed "Interactions" (although the "Trial" MAY include other interactions such as multiple-choice feedback):
    1. A null "Interaction" (blank screen) is shown. The parameter *latency* describes the duration of this "space".
    2. The "Stimulus" is exposed.
        a. If the ISI is set to zero (or less) we assume that the "Trial" consists of exposure of the "Stimulus" only (without the former "Interaction").

vi. A *Stimulus Exposure Time* (SET)—this is the duration for which the "Stimulus" is exposed to the participant. This is a parameter of the "Task", which a "Trial" inherits.
    1. If the SET is 0 (or less) then we assume no limit is enforced upon the duration of exposure of the "Stimulus" (this way, we don't need a separate "enabling flag" for SET).
    2. Otherwise, the SET represents the maximum duration of exposure of the "Stimulus" to the participant.
    3. If the SET is greater than 0, it could be possible that the "Stimulus" is exposed to the participant for an amount of time less than SET.
        a. This is the case, if we allow keyboard events originating from the participant, to end an exposure of a "Stimulus".

vii. A "Stimulus" *type label*, which is an inherent property of the "Trial", in the context "Stimulus-related Task". Since the selection of "Stimuli" for the task are selected and ordered pseudo-randomly, and derived from "Stimuli Pool"(s), which are allowed to contain "Stimuli" of one or more types (e.g., Word, Image, etc.) then the "Stimulus" *type label* is property that may vary from one "Trial" to the next.

viii. A "Stimulus" *identifier*, which uniquely identifies the "Stimulus" that was exhibited in the "Trial". Typically it would be adequate to allow this identifier to take string values, allowing it to represent an image file name (in the case of picture "Stimulus") or a sequence of characters (not including any newline or other special characters) in the case of word "Stimuli".

ix. A "Stimulus Pool" index, which uniquely determines the "Stimulus Pool" from which the "Stimulus" presented on this "Trial", was drawn.
    1. More than one "Stimulus Pool" index may be recorded among the parameters for an "Orientation Task".
    2. Only one "Stimulus Pool" index is recorded, per trial, as determined by the results of the pseudo-random sampling.

x. The *Mechanical Turk Worker ID*, if appropriate. This is an inherent property of the overall experiment, so it applies to each "Trial", but it need only be recorded once (per experiment).

xi. The *participant response* given—we assume that this datum is collected as the first key press value recorded during an interaction, that belongs to the list of "admissible" values for that interaction (the exception to this rule is the option to collect free-form text, or word responses, in which case the datum collected is the word/phrase reply)
    1. E.g., if "m" or "n" considered as "the" admissible key presses for a given interaction, e.g., during a "Recognition Test", other key presses are ignored.
    2. Only one admissible keyboard event may be received during the "Interaction".
    3. If no admissible keyboard events are received during the "Interaction", the participant response data field will be set to the NULL (N/A) value.

*xii.* A *Task Feedback Type index:* this is an inherent property of the "Task", if the "Task" is an "Orientation Task" this could be set to correspond to NULL, or one of the following options:
    *1.* Emotional Valence Option (1 to 5 scale from negative to neutral to positive)
    *2.* Memorability of "Stimulus" Option (1 to 10 or memorable, forgettable, neither)
        *a.* For the "Recognition Task" similar feedback options are available, except in the case of "Recognition Task', the above two options are replaced by a "Feedback Interaction" (in question-answer format) assessing how strongly the participant believes in the assessment of déjà vu, that they just provided.

*h.* We will subsume the above "Emotional Valence Option" and "Memorability of Stimulus Option" in terms of the concept: an

"Interaction" of "Feedback" type. We will require that "Feedback interactions" be permitted constituents of a "Trial", where:

*i.* A "Feedback" "Interaction" is an "Interaction" where the "Stimulus" presented on the screen, is a question (where possible responses are provided).

*ii.* An "Instruction" interaction is a "Feedback" interaction that displays a "Stimulus" of text type (as opposed to image type) but requires no response. So an "Instruction" task consists of a single interaction of this type.

iii. A "Delay" interaction is similar to the above, except it likely consists of a video stimulus unrelated to the other Stimuli. A "Delay" task consists of a single interaction of that type.

iv. A "Feedback" task is a sequence of atomic "Feedback" "Interactions", parameterized by the list of (textual) questions (which are, in fact, "Stimuli" of the textual variety).
    1. There is one "question text" for each "Trial" of the "Response Task", and one set of possible response texts, for each question (this could be an index instead of a set of values, if the multiple choice answer possibilities are redundant, which they are).
    2. The possible responses to a given question-stimulus are to be determined from a list of possible question-response formats.

v. Then, "Stimulus-related task" consists of a sequence of "Trials" each consisting of the following interactions:
    1. A "blank" interaction according to ISI,
    2. An interaction exposing the Stimulus for a number of mS up to SET (Stimulus Exposure Time)
    3. A "Feedback Interaction" of question/answer type (typically YES/NO), in the case of the "Recognition Task" this might be wedded to the presentation of the "Stimulus", and the admissible replies limited to {m,n}.
    4. Presentation of confidence scale (or generally, a multiple choice question).

i. A "Stimulus-related Task" has at least three possibilities for "Transition Option" pertaining to presentation of "Stimuli".
    i. Specified constant exposure time to present "Stimulus", preceded by a constant exposure of "blank" space (for ISI).
        1. This option is represented by a positive value for SET, we assume that if SET>0, then SET is "enabled".
        2. Termination of "interaction" by key press is disabled.

ii. Each stimulus stays on the screen until the subject makes a key-press response (e.g., for the orienting task, optionally the participant may rate the "Stimulus" as positive, negative, or neutral, or e.g., for the "Recognition Task" the user responds with a key-press to indicate "déjà vu" or not)
    1. This option is represented by disabling "SET" and by using a positive value for ISI.
    2. Termination of "interaction" by key press is enabled.

iii. The current "Stimulus" presentation "Interaction" expires upon key press, without any interval.
    1. In this case, SET has been set to 0 (SET is disabled) and the ISI has been set to 0.
    2. Termination of "interaction" by key press is enabled. The list of admissible key presses is set to be inclusive of all possibilities.

## Works Cited

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