

A Appendix of Extended Task Descriptions

This appendix aims to elaborate each core task from the core task list (Table 1 in the main material). This includes the rationale behind each task image, the task criteria used to identify a task, input and output modality task descriptions, and further elaboration of application and definition. The material is designed to be useful as a starting point to further discuss or produce exhaustive reviews of individual core tasks.

- (1) **Task Image:** A proposed iconographic image representing the task's main characteristics.
- (2) **Task type:** Tasks can be either motor or mental tasks. Mental tasks imply only cognitive work. Motor tasks imply motor control work in addition to cognitive work.
- (3) **Proposed Definition:** For each task, the proposed final definition is shown along with other definitions related to the pointing concept. When there are multiple definitions for a term, we show only the most relevant definitions of the concept.
- (4) **Sub-concepts:** An explanation of each conceptual element used in the iconographic image of the task and terms related to it.
- (5) **Task criteria:** A set of proposed abstract criteria which can be used to identify a given task. The criteria are based on our own evaluations. Lists soft criteria ("*May include.*") and hard criteria ("*Must include.*").
- (6) **Output/Input Modality Viewpoint:** Tasks can be defined from either an input-device or output-device viewpoint. For example, when defining pointing from an input-device viewpoint, pointing refers to a user's real-world interactions, but not necessarily how the system augments these interactions (for example, pointing using a Nintendo Wii controller). When defining pointing from the output modality viewpoint, it refers to user interactions as they are portrayed on the screen or game. For example, users may point at 2D elements using a virtual cursor controlled by arrow keys instead of a pointing device. The same task may therefore change its definition in input modality viewpoint and output modality viewpoint.
- (7) **Application Areas:** Exemplifies how the task concept's has been reviewed, defined and used in HCI and game scholarship.
- (8) **Related Definitions/Concepts:** Relevant or closely aligned concepts dictionaries and from the exemplified work (if any).
- (9) **Author Notes:** Miscellaneous notes that may elaborate differences to other tasks or what goes beyond scope of the definition.
- (10) **Game Examples:** We collected screenshots of games showcasing each core task to contrast different ways the tasks take shape in practice. Where possible, we primarily included games available from web browsers or as free download, to allow readers to test the interactions. The screenshots are shown for education and research purposes only and any depicted visual asset belong to the respective cited copyright holder.

A.1 Aiming Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Accurately pointing at a target (possibly using a device) and/or predicting the collision between two objects, without outcome signification."
Definition adapted from Refai et al. [114] with terminological changes.

Sub-concepts:

- (1) **▶ Subject:** The controlled object whose trajectory will be determined in the aiming task.
- (2) **🎯 Target:** *destination, objective.* The object which the user aims to hit with the subject.
- (3) **..... Predicted Trajectory:** *motion.* A line indicating the (invisible) trajectory the subject is predicted to take in the aiming task.
- (4) **↗ Speed:** Lines indicating the subject is in movement, as a result of being cast.

Task Criteria:

- (1) Must include deciding the subject's course, based on a prediction of collision between the subject and the target without signification of the outcome.
- (2) May include searching for a target.
- (3) May include explicit subject *activation* (launch), after which its (ballistic) trajectory cannot be manipulated.
- (4) May include a temporal delay between aiming and resulting target arrival feedback. During this delay the subject moves on a trajectory towards the target.
- (5) May include influence from environment factors such as gravity or wind, hindering accurate predictability of the outcome as known from e.g. pointing tasks.

Output Modality Viewpoint:

Aiming refers to an aiming interaction as they are portrayed on the screen or game, where users' aim determines the outcome through an often unknown relationship. Aiming is often used in context of e.g. throwing objects towards other objects with emphasis on the need to determine how to throw the object as being the challenge of the task.

Input Modality Viewpoint:

Aiming refer to users' real-world interactions with devices that facilitate the ability to aim, an interaction mostly present in natural user interfaces like Kinect or with gesture-based interfaces like Nintendo Wii, where it is possible to buy hardware attachments for sports or shooting which afford users to aim (see e.g. McArthur et al. [99]'s comparison).

Application Areas:

Aiming has been studied in relation to human sensorimotor coordination in ball throwing in motor neuroscience [38]. Within HCI, game scholarship studied how to assist users in aiming tasks, through environmental changes (e.g. gravity, magnetic force) that makes aiming at targets easier [64, 81]. To our knowledge, only Refai et al. [114] has formally defined aiming. We are not aware of any aiming task literature reviews.

Related Definitions:

"To direct a course." (Dictionary Definition, Merriam Webster)

"Accurately pointing at a target (possibly using a device) and/or predicting the collision between two objects, without feedback." Refai et al. [114].

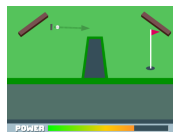
Author Notes:

The emphasis in *Aiming* is that an object moves from A to B, with a supposed unpredictable course taken between departure and destination and a small to long delay between user activation and feedback. In game environments, these characteristics are represented by virtual tools (darts, arrows, canon balls) in combination with environment and physics (wind, weather, gravity). Eliminating these factors, aiming tasks eventually becomes pointing tasks.



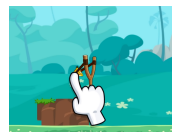
Full Tilt! Pinball [G7]

Players aim by timely activating two flippers to launch a ball towards score-giving targets.



The Skyscraper Minigolf [G38]

Players aim by choosing a direction and power level to fire a golf ball on a minigolf course.



Angry Birds [G18]

Players aim by dragging a slingshot which flings a bird towards a construction site.

A.2 Pointing Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Accurately pointing at an accessible target with feedback about current pointing position." [114]
Adapted from Refai et al. [114] with terminological changes.

Sub-concepts:

- (1) **Subject:** *pointer, cursor*. An object which indicates user's current position, often in the form of an arrow, dot or crosshair.
- (2) **Target:** *destination, objective*. The object which the pointer aims to point on.
- (3) **Trajectory:** *motion*. A line indicating the distance the pointer has travelled, to indicate that the pointer is in motion.

Task Criteria:

- (1) Must include the presence of a pointer to help users assert the trajectory needed and signify the outcome.
- (2) Must include the need to move from a current position to the target.
- (3) Must include clear general signification of whether pointer position and target position match.
- (4) May include searching for a target if its position is unknown.
- (5) May include providing confirmation when the user deems the target found.

Output Modality Viewpoint:

Pointing refers to user interactions as portrayed in the game. For example, users may point at 2D elements using a virtual cursor controlled by arrow keys. In the output modality viewpoint, this may be done through other means than standard pointing devices.

Input Modality Viewpoint:

Pointing refers to users' real-world interactions, but not necessarily what these interactions are augmented into by the system. For example, pointing at the UI elements using a nintendo Wii controller.

Application Areas:

Pointing is defined in the ISO 9241-9 "Ergonomic requirements for office work with visual display terminals (VDTs)" [52], and researched in context of input device throughput using Fitts Law [50] in virtual 2D pointing tasks [99], in 3D pointing tasks [28], and lots of kinematic research [97, 119, 125]. In game contexts, pointing has been evaluated to e.g. compare game hardware like thumbsticks [110] and addons like 'wiimote' gun attachments [99]. Outside HCI contexts, pointing is studied in its gestural form e.g. linguistics [66]. As a task, pointing has mainly been defined through e.g. ISO 9241-9's *point-selection task* and standardized in HCI [125].

Related definitions:

"To indicate the position or direction of especially by extending a finger." (Dictionary Definition, Merriam Webster)
"[An] operation with a graphic user interface in which an input device is used to move a small display image (such as a pointer) to a specific location on the display". (ISO 9241-9) [52]

"Accurately pointing at a target with feedback about current pointing position." Refai et al. [114]

Related Concepts:

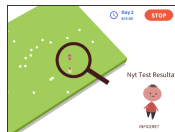
Pointing device: refers to hardware designed to control/solve pointing tasks, like a mouse.

Point-and-click: refers to a game genre in which interactions are made up of pointing and activation.

Target-to-target pointing task [76], Point & teleport locomotion task [56], Point selection task (ISO 9241-9 [52])

Author Notes:

Unlike Aiming, *Pointing* matches where users' intent to point to where they actually point. The pointing task challenges players in *where* to point and *how fast* to point. Pointing often consists of *Move* actions, optionally followed by an *activation* action to confirm the intended target.



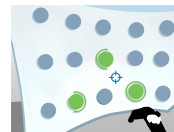
Infection Detective [G17]

Players hover a looking glass over a population to find and isolate infected persons before the infection spreads.



Osu! [G14]

Players move their cursor to hit targets, steer sliders or spin spinners in synchronization to music.



Whack-A-Mole VR [G16]

Players move a crosshair around to point at circular green targets amidst half-circular green distractors.

A.3 Steering Task

Image:



Task Type:

Motor Task

Proposed Definition

"Moving or guiding a subject along a trajectory."

Definition by Refai et al. [114] with terminological changes.

Sub-concepts:

- (1) **Subject:** The controlled object being steered, vehicle, movable object or the users' themselves.
- (2) **Obstacle:** *obstruction, barrier.* Objects in the environment which constraints or obstructs the path to the users' target.
- (3) **Target:** *destination, objective.* The position or direction which users' aim to steer their subject to.
- (4) **Trajectory:** *motion.* A line between subject and target indicating that the subject is in motion towards its target.

Task Criteria:

- (1) Must include the presence of one or more obstacle constraining the user's path to the chosen target.
- (2) Must include the need to move from a current position to a target position or target direction.
- (3) Must include clear general signification of whether subject position and target position match.
- (4) May include a search for the target prior to or during steering, if its position is not known.
- (5) May include providing confirmation when the user believes the target has been found.

Output Modality Viewpoint:

Steering refers to the movement of a user-controlled virtual object to a destination. For example, users may steer a virtual car around a 2D or 3D environment to reach the racing line.

Input Modality Viewpoint:

Steering refers to the users creating motion of themselves or of physical objects. Some Virtual Reality games, for example, require users to physically move around their physical environment.

Application Areas:

In HCI, steering has been systematically explored via the tunnel steering law [3], which applies to 'trajectory-based interactions' such as steering in 2D and 3D space [3]. Within games, various subtopics within steering has been explored, such as semi-autonomous steering [87] (games) and input device preferences for racing games [117, 135].

Related Definitions:

"To control the course of." (Dictionary Definition, Merriam Webster [101]).

"Moving or guiding an object along a path. (Refai et al. [114]).

Described as trajectory producing motion or constrained motion by Accot and Zhai [3].

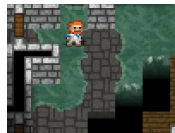
Related Concepts:

Movement Speed: The speed at which the object being steered moves.

Tunnel width: In tunnel steering, the tunnel width directly impacts the difficulty of a tunnel steering task [3].

Author Notes:

Steering tasks are characterized by obstacles present in the environment, requiring users to consider direction and perform consecutive movement actions to steer around them.



Pixel Dungeon [G42]

Players steer a character through the underground, where time passes with each grid-based move.



X-Moto [G1]

Players steer a motocross by throttling, braking and jerking it in a physically simulated side-view landscape.



Speed Dreams [G39]

Players steer a racing car along a race track whilst being projected as the driver.

A.4 Drawing Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Marking or laying out content in an area."

Simplified description from Zabramski and Stuerzlinger [147].

Sub-concepts:

- (1) **Subject:** *pointer, cursor, tool.* the object which manipulates the environment.
- (2) **Target:** *destination, objective.* an area or position in the environment being manipulated.
- (3) **Content:** *depiction.* That, which is added, removed, or changed within the environment.

Task Criteria:

- (1) Must include the presence of a subject (cursor) controlled by the user, which manipulates the environment.
- (2) Must include moving and activating the subject to consecutively to create content.
- (3) May include an intention to create patterns which can be recognized as a depiction of an object of interest.

Output Modality Viewpoint:

Drawing refers to the task of visually laying out virtual elements in an area using a virtual tool capable of manipulating the virtual environment, by adding, removing or changing it.

Input Modality Viewpoint:

Refers to users' interacting with a virtual drawing board, by holding a pen-like input device, mimicking the act of drawing with regular pen and paper by recording sensing position.

Application Areas:

In HCI, Zabramski and Stuerzlinger [147] have reviewed drawing tasks in terms their formal boundary, their use in HCI. They demonstrated how to analyse drawing tasks by employing the W⁶ framework. Their definition describes the use of a tool applied onto a medium. They evaluated suitable input devices for drawing tasks [146]. Their review of drawing tasks does not explicitly consider drawing from input and output modality viewpoints. In game scholarship, sketch-based gameplay has been used to motivate sketching practice [145] (games).

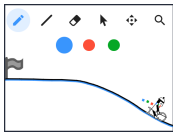
Related Definitions:

"To create a likeness or a picture in outlines." (Dictionary definition, Merriam Webster)

"The spatio-temporal interaction foregrounding the trace of a trajectory performed by the user-controlled tool on a medium." (Zabramski and Stuerzlinger [147])

Author Notes:

Drawing requires performing a series of well thought-through movements to arrive at a desired visual arrangement. Although Accot and Zhai [3] claim their steering law applies to writing and drawing, this is later rejected by Zabramski and Stuerzlinger [147] in their review of drawing tasks.



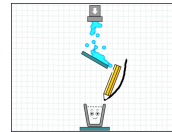
Line Rider [G43]

Players draw lines to form a landscape, on which a character will ride a sled.



Quick, Draw! [G12]

Players draw an object while a machine attempts to guess it in a limited timeframe.



Happy Glass [G37]

Players draw lines strategically to guide as much water as possible into a glass.

A.5 Activation Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Initiating another mechanical system, function, or item."
Adapted from UGO's activation mechanic [40].

Sub-concepts:

- (1) **Subject:** *pointer, cursor, signifier.* The object which performs the activation.
- (2) **Target:** *objective.* The object being activated.
- (3) **Inactive Target:** An alternative target which has not been activated.
- (4) **Target Feedback:** The targets response to becoming activated.

Task Criteria:

- (1) Must include a target which affords activation.
- (2) Must include that users perform at minimum one or more actions that altogether results in activation.
- (3) May include the need to make a selection if more than one target is available.
- (4) May include feedback from the target, when it's activated, reflecting the change in state.

Output Modality Viewpoint:

Activation refers to the act of initiating something (e.g. game mechanic) in the environment, like pressing a virtual button.

Input Modality Viewpoint:

Refers to users' press of a button to send a single command or input to the system.

Application Areas:

In HCI, activation has been reviewed from an input device viewpoint, examining the neuromechanics of buttons by Oulasvirta et al. [106]. In games, activation has been used with respect to making assessments of player reaction time [82]. In the UGO, activation is a formally defined game mechanic, covering any type of binary initiation of a mechanical system [40].

Related Definitions:

"To make active or more active." (Merriam-Webster Dictionary [101]).
"Physical buttons are electromechanical devices that make or break a signal when pushed, then return to initial (or re-pushable) state when released." (Oulasvirta et al. [106]).
"The mere initiation of another mechanical system, function, or item." (Debus [40]).

Author Notes:

This core task category represents the single button press, a motor task often used in context of mental tasks like selection. Activation often takes place at the action-level as part of a different task, instead of being a task of its own. However, some games classify as activation tasks, because their interaction work consists of many consecutive activations, like e.g. Cookie Clicker [G22].



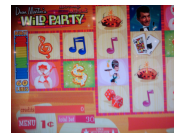
All My Dice [G33]

Players roll their dice until all dice show the same number faster than the opponent.




Cookie Clicker [G22]

An incremental game in which players continuously clicks to earn income, which they can spend to increase passive income.



Slot machines

Digitized one-armed bandits are chance-based games involving a single activation, to gamble money. Image is "Dean Martin's Wild Party" by NoirDamedotCom (CC-BY-SA 2.0) .

A.6 Typing Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Performing a sequence of input activations to enter data."
Our own definition based on Merriam-Webster [101].

Sub-concepts:

- (1) **Subject:** *pointer, cursor, indicator.* An object indicating the position adjacent to where typing takes place.
- (2) **AB Data:** *text.* The resulting data shown as a result of the typing.

Task Criteria:

- (1) Must include a sequence of activation actions in an environment where users input data.
- (2) May include the construction of words, phrases, code, commands or other situationally meaningful data to the environment.
- (3) May include involve deletion/modification of data.

Output Modality Viewpoint:

Typing refers to the sequential occurrence of data (e.g. letters) on a screen in response to input activations performed by users, usually through a keyboard-like (virtual) interface.

Input Modality Viewpoint:

Refers to the act of pressing input buttons (e.g. letters, numbers) on touch- or button-based keyboard hardware.

Application Areas:

Typing may have originated from the act of writing with typewriters, which has since transitioned to describe writing by operating a keyboard (e.g. *typist*) [45]. The act of typing has been explored and compared to other input modes like handwriting, printing, marking and keying in terms of input rate [43]. KLM is a model in the GOMS family of activity theory specifically designed to model typing performance [23]. Typing tasks were explored in HCI, for example in contexts of input sequence mining [139] and stress detection when typing under pressure [91].

Related Definitions:

"To write something on a typewriter or enter data into a computer by way of a keyboard." (Merriam-Webster Dictionary [101]).

"The arranging of type in an appropriate manner to suit a particular purpose." (Eckersley et al. [45], *Typography*).

"(I) A person who sets type, either the keyboard operator (who is essentially a typist) or the compositor (who is responsible for interpreting the type specifications and encoding the manuscript)." (Eckersley et al. [45], *Typesetter*).

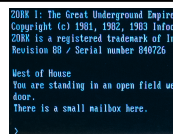
Author Notes:

Typing tasks typically occur on keyboards, but also occur on virtual keyboards, when no keyboard hardware is available. Typing in games is well-known in text-based adventure games like Zork.



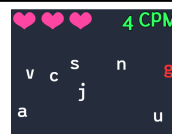
Wordle [G21]

Wordle is a word guessing game. For each typed word, hints are given as to which types letters were correct or wrong, informing the next guess.



Zork [G35]

Zork is a text adventure game, in which players types commands to interact with the game. Image by Marcin Wichary (CC-BY 2.0) [1].



Type Off [G30]

In Type Off, letters move from left to right and players must type each letter before they reach the end of screen.

A.7 Selection Task

Image:



Task Type:
Mental Task

Proposed Definition:
"Making a choice."
Adapted from Merriam Webster [101].

Sub-concepts:

- (1) **M**ental: *cognitive*. This task takes place in the mind.
- (2) **B** Selection: *choice*. An option, emphasized to indicate the user's decision to select it.
- (3) **AB** Options: Non-emphasized options which indicate the presence of alternative options to the user's chosen option.

Task Criteria:

- (1) Must include the presence of options from which a selection needs to be made.
- (2) May include the use of deduction, hypothesis evaluation or other forms of reasoning [126].

Output Modality Viewpoint:

Selection is made in context in which options are presented in an environment (e.g. "which meaningful outcome should I choose?").

Input Modality Viewpoint:

Selection is made in context of operating an input device (e.g. "which button should I press?") or interacting with the user's physical environment (e.g. "which physical movement should I perform?").

Application Areas:

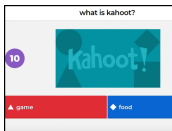
The notion of selection (or making a choice) has been studied and reviewed in psychology contexts, such as: 1) in relation to phenomenon like choice overload [32] (e.g. Hick's Law), 2) in relation to the grounds in which the selection is made (based on e.g. deduction or hypothesis evaluation [126]), and 3) as tasks like e.g. the Wason Selection Task [141]. In game scholarship, Jiang et al. studied gamers' reaction time when solving multiple choice tasks [82].

Related Definitions:

"To make a choice." (Merriam Webster Dictionary [101]).

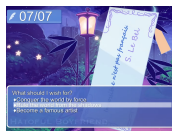
Author Notes:

Notably prominent in Quiz games and card games, where the nature of the selection (the basis of which you make your selection) becomes more important than the interaction of articulating the choice itself.



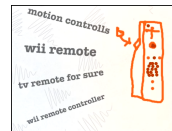
Kahoot! [G3]

Players make a selection to correctly answer quiz questions and receive points in a competition against others.



Hatoful Boyfriend [G19]

Players make selections to make progress in a narrative, and influence their relationship to other characters.



Drawful [G20]

Players first describe a drawing's resemblance, then select among self-proposed answers and receive points for selecting the most voted option.

A.8 Configuration Task

Image:



Task Type:
Mental Task

Proposed Definition:

"Arranging items based on particular criteria (e.g. similarity)."
Our own definition, inspired by Galli [57].

Sub-concept:

- (1) **Mental:** *cognitive*. This task takes place in the mind.
- (2) **Item:** *element, piece*. The object which is thought to be configured.
- (3) **Operation:** The operation which is mentally imagined to meet the task criteria (goal), e.g. rotating, positioning, or ordering.

Task Criteria:

- (1) Must include the presence of one or more items on which the configuration is attempted.
- (2) Must include the possibility of spatial or temporal operations that can be mentally imagined on the item in question.
- (3) May include the presence of an environment (other objects), to which the item is being configured in relation to.

Output Modality Viewpoint:

Configuration of virtual elements, based on features simulated within a virtual environment.

Input Modality Viewpoint:

Configuration of physical elements in the context of an input device that require it for interaction.

Application Areas:

Configuration refers to the mental work of solving visuospatial challenges, like packing problems [94] found in e.g. jigsaw puzzles or tangram puzzles or sorting problems, which involves item arrangement, including *ordering* and *clustering* tasks [57], which we for the time being cover within *configuration* until differences are better understood. In game scholarship, configuration tasks can for instance, be observed in Vayanou et al.'s study of designing collaborative jigsaw puzzle game design [136]. Our review did not yield configuration tasks to be a formally established in HCI or game scholarship.

Related Definitions:

"Relative arrangement of parts or elements" (Merriam Webster Dictionary [101]).

"Grouping a set of objects in such a way that objects in the same group (called cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters)." (Galli [57], Clustering).

"Arranging items of the same kind, class, nature, etc. in some ordered sequence, based on a particular criterion." (Galli [57], Ordering).

Author Notes:

The *configuration task* aims to cover *ordering* and *clustering* tasks [57]. We chose to merge these two tasks to a broader covering task that covers any kind of arrangement, that does address any specific criteria for arrangement, such as order and sequence. Also, we do not want to encode a specific purpose, where ordering and clustering both imply a specific kind of data and a specific expected outcome. However, ordering and clustering could be considered more specific sub-task categories of configuration.



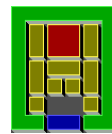
PipeWalker [G34]

Players configure pipes to create complete circuits.



Tetravex [G11]

An edge-matching puzzle where players configure numbered cubes in a square grid by matching numbers on each side.



Klotski [G9]

Players slide blocks horizontally or vertically using as few moves as possible to arrive at the configuration required.

A.9 Memory Task

Image:



Task Type:
Mental Task

Proposed Definition:

"Memorizing and recalling sets of items, sequences, or mappings."
Definition adapted from Refai et al. [114] with terminological changes.

Sub-concepts:

- (1) **Mental:** *cognitive*. This task takes place in the mind.
- (2) **Search and Retrieve:** Metaphor for the mental search and retrieval associated with remembering.

Task Criteria:

- (1) Must include the presence of a cue, indicating the need to retrieve or memorize an item.
- (2) May include the presence of information to retain in either short- or long-term memory.

Output Modality Viewpoint:

The memory task is about memorizing or retrieving information as required by the virtual environment, for example a username.

Input Modality Viewpoint:

The memory task relates to the needs of interacting with an input device, for example remembering the mapping between a pressing button and a corresponding action outcome.

Application Areas:

The workings of short-term memory and long-term memory has been studied extensively in psychology, under a variety of tasks like 1) the *free recall memory task* [53] in which subjects read a list and instructed to report as many as possible in no particular order or 2) the *serial recall task*, in which items must be reported back in a specific order [140]. In game scholarship, El Agroudy et al. studied how to turn memory experiments like e.g. word recall into entertaining mobile games [46].

Related Definitions:

"A particular act of recall or recollection" (Merriam Webster Dictionary [101]).
"Memorizing and/or retrieving sets of items, sequences, and/or mappings." (Refai et al. [114])

Author Notes:

Memory tasks are closely related to spatial memory tasks, but cover tasks where the spatial information does not play the key role. They also relate closely to selection tasks, but as tasks, they emphasize the nature of the recall, which does not necessarily require selection, just like selection does not have to rely on recall. The memory task is a high-level category, but can be conceptually divided further down by subtype, like e.g. episodic memory (recalling specific events), semantic memory (recalling factual knowledge), or implicit memory (unconscious habits).



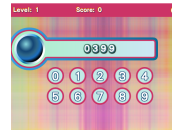
Hieroactive [G10]

Players memorize Egyptian glyphs and are subsequently challenged in their ability to form sentences.



The New One [G27]

Players memorize shapes to identify the new shape previously not present.



Sequence Memory [G26]

Players memorize presented numbers and are challenged to enter each number in order afterwards.

A.10 Spatial Memory Task

Image:





Task Type:
Mental Task

Proposed Definition:

"Remembering the location of items in a space without persistent cues."
Definition adapted from Refai et al. [114] with terminological changes.

Sub-concepts:

- (1)  **Mental:** *cognitive*. This task takes place in the mind.
- (2)  **Location:** Metaphor for an object's position in space.

Task Criteria:

- (1) Must include the presence of an already known item, whose location needs to be identified or stored.
- (2) Must include the presence of a spatial grid featuring one or more dimensions, within which the items' location can be pinpointed.

Output Modality Viewpoint:

The spatial memory task involves memorizing or retrieving spatial information, as defined by the virtual environment and its spatial dimensions perceived by the user.

Input Modality Viewpoint:

The spatial memory task involves the spatial location of information on an input device, such as identifying or memorizing the location of a button to interact.

Application Areas:

Psychology has studied and used games as medium to assess and practice spatial ability. Games like the "Simon" game require players to memorize sequences of colors, appearing in four different locations on a circle. Lin et al. and Van de Weijer-Bergsma et al. studied how to develop a game to let players practice spatial orientation [92, 134]. They did not formally define spatial memory, but Lin et al. relied on a measure of spatial ability from The Nine Box Maze Test [107].

Related Definitions:

"[...] to detect or reason about relationships within or between objects in space." (APA Dictionary of Psychology on spatial ability [10]).

"[...] spatial memory includes storage of information about objects and their location." [107] (used by Lin et al. [92]).

Author Notes:

Spatial memory games are e.g. games where users are prompted to remember locations of two matching items. In these games, designing the spatial memory task becomes equally important as designing the motor task in which users articulate their recall. Spatial memory and memory is often closely tied together - we suggest categorizing one or the other by how meaningful the spatial information is to the task at hand.



Simon [G4]

Players memorize a sequence of colored buttons appearing in four different locations and repeat the shown sequence by pressing them.



Memory [G25]

A game of concentration in which players memorize locations of cards to pair them as quickly as possible.



Blind Spot [G24]

Players memorize locations of disappearing shapes and subsequently estimate what used to be each shape's center-most point.

A.11 Detection Task

Image:



Task Type:
Mental Task

Proposed Definition:
"Consciously perceiving a stimulus, such as sound, light, or vibration."
Adapted from Refai et al. [114].

Sub-concepts:

- (1) **Mental:** *cognitive*. This task takes place in the mind.
- (2) **Stimulus:** An object in question whose change in state is to be detected (e.g. a lightbulb lighting up).

Task Criteria:

- (1) Implies a stimulus which may or may not be present, for example in the form of an object changing state.
- (2) May imply subsequent recognition, classification and identification.
- (3) Used as a sub-task in a motor task to drive interactions.

Output Modality Viewpoint:

Detection tasks involve detecting stimuli in the virtual environment. (e.g. detecting the presence of a virtual menu button).

Input Modality Viewpoint:

Detection tasks involve detecting stimuli in the physical environment, to facilitate interaction with the virtual environment (e.g. detecting the presence of a physical button).

Application Areas:

In cognitive psychology, simple reaction time measures involving detection are used as a way to measure human information processing times [35]. For example, Ratcliff et al. measured the effects of aging on reaction times in two activation tasks [112], which are based on "signal detection paradigms" showing either a low or high number of symbols on a computer screen.

Related Definitions:

"To discover or determine the existence, presence, or fact of" (Merriam Webster Dictionary [101]).

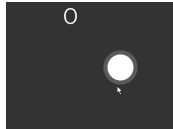
Author Notes:

This definition is scoped to conscious human sensory detection. Detection is also used conceptually to describe e.g. as unconscious detection (e.g. body reflexes), and machine-based detection (e.g. sensors).



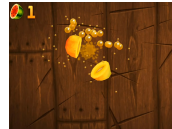
Quickdraw [G28]

The player must fire in response to a cue as fast as possible before an opponent does.



POP [G15]

Players must pop each growing bubble before they grow beyond a specific size.



Fruit Ninja [G13]

Players slice fruit as they appear on the screen to survive. Different fruits have different properties when sliced.

A.12 Discrimination Task

Image:



Task Type:

Mental Task

Proposed Definition:

"Determining that there is a difference between two stimuli (e.g., determining that two colors or two sounds are different)."

Definition imported from Refai et al. [114].

Sub-concepts:

- (1) **Mental:** *cognitive*. This task takes place in the mind.
- (2) **Stimulus:** An object in question whose change in state is to be detected (e.g. a lightbulb lighting up).
- (3) **Comparator:** An object whose state is compared to the stimulus to assert whether discrimination is possible (e.g. an unlit lightbulb).

Task Criteria:

- (1) Implies a stimulus which may or may not be present, for example in the form of an object changing state.
- (2) Implies the presence of one or more other stimuli (comparators) or an environment whose state is compared to the stimulus.
- (3) May imply subsequent recognition, classification and identification.
- (4) Used as a sub-task in a motor task to drive interactions.

Output Modality Viewpoint:

Discrimination tasks involves discriminating between stimuli within the virtual environment.

Input Modality Viewpoint:

Discrimination tasks involve discriminating between stimuli in the physical environment, e.g. discriminating between two buttons on an input device.

Application Areas:

Widely used and reviewed in psychology. There is a large body of work in cognitive psychology on visual discrimination tasks and related effects like for example inhibition of return [108] (a bias towards attending an already attended location) or visual discrimination efficiency (e.g. determining how small differences can be detected by humans when looking at noise patterns) [21].

Related Definitions:

"The act of making or perceiving a difference" (Merriam Webster Dictionary [101]).

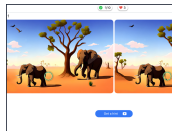
Author Notes:

The main differentiator between discrimination and detection, is that for discrimination two or more stimuli are present and compared, whereas detection concerns itself with the absence or presence of a single stimulus.



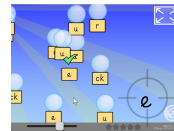
Color React [G6]

Players must determine which outer-most color corresponds to the inner-most color as fast as possible.



Find The Difference [G31]

Players are tasked to visually compare two images and mark their differences.



Phonics Pop [G5]

Players identify letters appearing on balloon based on a reference letter shown visually and pronounced.

A.13 Prediction Task

Image:



Task Type:

Motor Task

Proposed Definition:

"Anticipating an event's occurrence to act on or synchronize with it."
Our own task definition.

Sub-concepts:

- (1) **Mental:** *cognitive*. This task takes place in the mind.
- (2) **Prediction:** The imagined moment in time an occurrence is expected to happen.
- (3) **Stimulus:** An object in question whose change in state is predicted (e.g. anticipating when the lightbulb lights up).

Task Criteria:

- (1) Implies a stimulus to be predicted, for example in the form of an object changing state.
- (2) Used as a sub-task in a motor task to drive interactions.

Output Modality Viewpoint:

Prediction refers to anticipating an event in a virtual environment with the intention to match an action to the event.

Input Modality Viewpoint:

Prediction refers to anticipating an event in the physical environment with the intention to match an action to the event.

Application Areas:

Prediction is often studied in relation to rhythm or synchronization within HCI and game scholarship. Rhythmic coordination is also called sensorimotor synchronization and has, for example, been studied as finger tapping to auditory stimuli in psychology [115]. In game scholarship, rhythmic coordination has been studied as a motivational factor to e.g. play co-located games (movement synchrony, like dancing together) [98] or exergames (motor-auditory synchrony, e.g. performing actions in synchrony to a song in Beatsaber) [5].

Related Definitions:

"The temporal coordination of a motor rhythm with an external rhythm." (Repp [115]).

"To declare or indicate in advance" (Merriam-Webster Dictionary, Predicting).

"The ability to select the precise moment for doing something for optimum effect" (Merriam-Webster Dictionary, Timing).

Author Notes:

The proposed prediction task definition implies a near-term response, as is suitable for most gameplay and HCI analysis (unlike other contexts like e.g. forecasting weather). Prediction is characteristic of reaction time tasks, where reaction time is determined by letting users detect a stimuli followed by a motor task like simple activation to give indication of the detection.



Dance Dance Revolution [G23]

Players predict the onset between moving arrows and corresponding stationary arrows.



Rope Skipper [G8]

Players make a character jump, predicting the onset of a rope swung under the character's feet.



Parappa The Rapper [G29]

Players predict the onset of their own rap line timely matching another character's rap line.

A.14 Search Task

Image:





Task Type:

Mental Task

Proposed Definition:

Finding a target in a set field of distractors; includes pattern recognition (determining the presence of a pattern amongst a field of distractors). Definition imported from Refai et al. [114], adapted to make it applicable to non-visual search tasks.

Sub-concepts:

- (1)  **Mental:** *cognitive*. This task takes place in the mind.
- (2)  **Looking Glass:** A visual metaphor which represents the act of searching.

Task Criteria:

- (1) Search tasks contains a target to be searched for.
- (2) Requires that the target has not yet been found.
- (3) Search is not tied to a particular modality, it covers, for example, auditory, visual and haptic searches.

Output Modality Viewpoint:

The user performs search within the virtual environment.

Input Modality Viewpoint:

The user performs search in their physical environment.

Application Areas:

In psychology, search tasks have been studied in the form of identifying auditory features in auditory searches [48] and identifying search strategies within visual searches, like e.g. feature and conjunction searches [132]. For example, Treisman and Gelade quantified visual search efficiency in human subjects by asking participants to press a button as soon as they located a specific letter among other letters on a white card [132]. In game scholarship, puzzle games have been created to make assessments of visual search ability [33] and pattern recognition ability [33]. Chesham et al. created a *search and match* task, in which users upon identifying their target, had to swap two tiles on a puzzle board. Raptis and Katsini studied the influence of field dependence-independence on visual searches by measuring eye trajectories in players who identified simple shapes within complex shapes in a game based on the *group embedded figures test* [111].

Related Definitions:

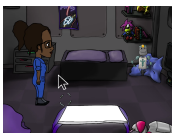
"To look into or over carefully or thoroughly in an effort to find or discover something" (Merriam Webster Dictionary [101]).

"Visual search is the ability to find target objects in complex visual scenes in everyday life." (Chesham et al.'s formulation [33], referencing Horowitz [72]).

(On developing the visual search paradigm) "The visual search paradigm allows us to define a target either by its separate features or by their conjunction." (Treisman and Gelade [132]).

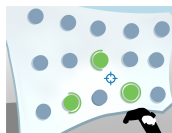
Author Notes:

Search, as a task, also has other higher-level meanings beyond the low-level perceptual task implied by core tasks, like information search (e.g. finding information on the internet) or exploratory search (e.g. discovery something without a specific target in mind) and related concepts like search queries, and browsing. Performing such higher-level tasks still involves lower-level mental and motor core tasks.



2080 [G32]

Players search for items, clues and locations to advance in the story.



Whack-A-Mole VR [G16]

Players search for a valid green circular target amidst distracting green half-circular targets.



Sound Horn [G36]

Players search for the origin of different sounds in a virtual environment and can play, record and swap sounds made by nearby objects.

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