**Appendix A: Heuristics for the application of Knowledge Type sub-codes**

**A.1 Search Sub-Codes and Heuristics**

| **Sub-Code Category** | **Sub-Code** | **Example Heuristics** |
| --- | --- | --- |
| **Intuitiveness** | Intuitive | - Non-verbal process (Bastick, 1982, 2003; Blackler, Popovic, & Mahar, 2010)- Guidance of attention to task-relevant features (Liu & Gale, 2011; Liu, Gale, & Song, 2007; Wolfe & Horowitz, 2017)- Efficient scanpath (Goldberg & Kotval, 1999; Mruczek & Sheinberg, 2005; Poole & Ball, 2006), indicated by short scanpath with few fixations (Goldberg & Kotval, 1999)- Non-exhaustive search, indicated by targeted spatial distribution of samples for each image (Goldberg & Kotval, 1999) |
| Partially-Intuitive | - Limited verbalisations of search process and visual attention (Bastick, 1982, 2003)- Irregular scanpath efficiency during search of an image (Goldberg & Kotval, 1999; Poole & Ball, 2006)- Alternating between intuitive and non-intuitive processes (Baylor, 2001)- Some backtracking (regressive saccades) to already searched areas of the image (Goldberg & Kotval, 1999; Poole & Ball, 2006) |
| Non-Intuitive | ­- Extensive verbalisation of search process and visual attention (Bastick, 1982, 2003)- Exhaustive search of visual features (Liu & Gale, 2011), indicated by spatial distribution of samples spread throughout the image (Goldberg & Kotval, 1999)- Inefficient scanpath (Goldberg & Kotval, 1999), indicated by long scanpath with many fixations (Goldberg & Kotval, 1999)- Extensive backtracking (regressive saccades) to already searched areas of the image (Goldberg & Kotval, 1999; Poole & Ball, 2006)- Frequent transitions between regions (Goldberg & Kotval, 1999), such as search with multiple transitions between the left and right displays |
| **Knowledge** | Perceptual | - Retrieval of knowledge of visual concepts for understanding and identifying objects and their associated meanings (de Jong & Ferguson-Hessler, 1996; Eraut, 1990). For example, short periods of search with frequent interruptions, indicated by brief dwell fixations, for explicit retrieval of knowledge for identifying objects- Verbalising the identity of objects during search activity |
| Procedural | - Knowledge of procedures and how to perform them (de Jong & Ferguson-Hessler, 1996; Phye & Sanders, 1992), indicated by applying search procedures for the performance of the x-ray screening task - Connected or sequenced actions (Eraut, 1990; Phye & Sanders, 1992), such as multiple search sequences linked together across several bags |
| Strategic | - Goal directed, structured and organised action incorporated into problem solving (de Jong & Ferguson-Hessler, 1996; Schraw, 1998). For example, search performed on a cluttered bag (or other wide-area affecting image-based factor) following strategic use of an IEF |
| Situational | - Ability to recognise and read a situation at a high level, to inform appropriate behaviour (Alexander & Judy, 1988; de Jong & Ferguson-Hessler, 1996; Klein & Hoffman, 1993). For example, immediately comprehending a situation through search activity to inform associated action |
| Insufficient | - Inability to perform search activity- Uncertainty in search indicated by multiple transitions between regions (Ehmke & Wilson, 2007; Goldberg & Kotval, 1999). For example, search activity with numerous transitions between the left and right display |

**A.2 Examination Sub-Codes and Heuristics**

| **Sub-Code Category** | **Sub-Codes** | **Example Heuristics** |
| --- | --- | --- |
| **Intuitiveness** | Intuitive | - Non-verbal process (Bastick, 1982, 2003; Blackler et al., 2010)- Immediate recognition of objects (Gauthier, 2010)- Short, highly focused fixations (Poole & Ball, 2006)- Low latency between fixations and transition to proceeding action (Blackler, 2008) |
| Partially-Intuitive | - Limited verbalisations during examinations (Bastick, 1982, 2003)- Limited repeat examinations of an object, indicated by only some backtracking (regressive saccades) (Goldberg & Kotval, 1999; Poole & Ball, 2006)  |
| Non-Intuitive | ­- Verbalisations indicating effortful process and deliberation during activity (e.g., ‘um, ah’, ‘what is that?’) (Bastick, 2003; Blackler, Popovic, & Mahar, 2003)- Lengthy dwell fixation (Goldberg & Kotval, 1999; McCarley, Kramer, Wickens, Vidoni, & Boot, 2004; Poole & Ball, 2006)- Multiple repeat examinations of an object, indicated by backtracking (regressive saccades) (Goldberg & Kotval, 1999; Poole & Ball, 2006)- Frequent transitions between regions (Goldberg & Kotval, 1999), such as multiple examinations of the same object while transitioning between the left and right displays |
| **Knowledge** | Perceptual | - Retrieval of knowledge of visual concepts for understanding and identifying objects and their associated meanings (de Jong & Ferguson-Hessler, 1996; Eraut, 1990)- Fixations with clear visual focus (e.g. focused fixation spatial density) (Goldberg & Kotval, 1999), for the purpose of identifying an object - Declarative understanding of objects and their features (Gauthier, 2010; Goldstein, 2010), indicated by naming objects as they are identified |
| Procedural | - Knowledge of procedures and how to perform them (de Jong & Ferguson-Hessler, 1996; Phye & Sanders, 1992) in relation to specific objects (e.g. identifying an umbrella and then engaging further examination to ensure no sharp object is being concealed)- Conditional reasoning (Anderson, 1986; Mayer & Wittrock, 2006), such as examination of one area of interest that initiates examination of related areas of interest (e.g. identifying what could be a detonator and examining areas of the image that could be other components of an improvised explosive device)  |
| Strategic | - Integrated performance of activity, characterised by planning and execution of efficient sequences of action for problem solving (de Jong & Ferguson-Hessler, 1996). For example, examinations performed among sequences of interface interactions also characterised by strategic knowledge- Identifying and facilitating learning situations (Ertmer & Newby, 1996; Phye & Sanders, 1992). For example, reviewing previous difficult images or objects when time permits |
| Situational | - Ability to recognise and read a situation at a high level, to inform appropriate behaviour (Alexander & Judy, 1988; de Jong & Ferguson-Hessler, 1996; Klein & Hoffman, 1993). For example, generating and recognising new information through examinations performed during problem solving, to inform associated action- Predictive inferences relating to the result of change caused by actions (Kirschner & Van Vilsteren, 1997; Salas, Rosen, & DiazGranados, 2009), such as examining the result of an IEF and explaining the expected outcome as it happens |
| Insufficient | - Inability to identify an object, indicated by an examination preceding a screener interaction requesting manual search. - Verbalisations indicating uncertainty over the identity of an object (“Um”, “What is that?’”, ‘”I’m not sure what that is?”)- Uncertainty indicated by multiple transitions between regions with repeat dwell fixations (Ehmke & Wilson, 2007; Goldberg & Kotval, 1999), such as multiple lengthy examinations of the same object while transitioning between the left and right displays- Hesitation and indecision (Lipshitz & Strauss, 1997), indicated by excessively long dwell fixations (Goldberg & Kotval, 1999; Poole & Ball, 2006) |

**A.3 Interface Interaction Sub-Codes and Heuristics**

| **Sub-Code Category** | **Sub-Code** | **Example Heuristics** |
| --- | --- | --- |
| **Intuitiveness** | Intuitive | - Non-verbal process (Bastick, 1982, 2003; Blackler et al., 2010)- Efficient and immediate interactions, indicated by low latency between prior action and interaction with the physical interface (Blackler, 2008)- Interacting ‘through’ the physical interface, indicated by maintaining focal attention on the visual display, without shifting focus to the physical interface during its use (Bodker, 1991; Popovic & Kraal, 2008) |
| Partially-Intuitive | - Limited verbalisations during the performance of activity (Bastick, 1982, 2003)- Some automation of low level processes, but higher level processes requiring attentive control (Baylor, 2001). For example, high latency between prior action and interaction with the physical interface, but absence of focus shift to the physical interface during its use. |
| Non-Intuitive | ­- Verbalisations and evidence of deliberation and reasoning (Bastick, 1982, 2003; Blackler et al., 2010) (e.g., “that’s a bit dark so I’ll just go black and white”, “I’m not sure what that is so I’ll just use the TIP button to make sure”)- Delayed and deliberative interaction indicated by high latency periods between antecedent action and interface interaction (Blackler, 2008)- Shifting visual attention to the physical interface, and maintaining focus on the physical interface, during its use (Bodker, 1991; Popovic & Kraal, 2008) |
| **Knowledge** | Perceptual | - Demonstrating knowledge about visual concepts and their meanings (Patterson, Nestor, & Rogers, 2007). For example, explaining specific visual features of an object or characteristic of an image during interface interaction |
| Procedural | - Knowledge of how and when to perform an action (de Jong & Ferguson-Hessler, 1996), For example, knowing how to applying various IEFs and having a general understanding of when they are suitable to being applied- Evidence of conditional reasoning and statement of simple production rules (if – then rules) (Anderson, 1982; Roda, 2011), such as stating “this is a cluttered bag so I’ll apply the black and white filter and fade through it”  |
| Strategic | - Identifying and facilitating learning situations (Ertmer & Newby, 1996), such as reviewing previous difficult images while using IEFs when time permits- Goal directed, structured and organised performance (de Jong & Ferguson-Hessler, 1996; Schraw, 1998) resulting in optimal solution (Gruber, 1989), such as clear statement of goal followed by multiple complimentary IEFs in sequence absent of trial and error- Adaptable problem solving (Phye & Sanders, 1992), such as recognising when a situation is unfamiliar and successfully applying an IEF strategy to overcome it  |
| Situational | Rich mental representation and understanding of situation (de Jong & Ferguson-Hessler, 1996; Eraut, 1990), demonstrated by an immediate comprehension of the on-screen image as a problem context and application of strategic interface interaction - Predictive inferences relating to the result of change caused by actions (Kirschner & Van Vilsteren, 1997; Salas et al., 2009), such as selecting an IEF based on an accurate understanding of the result it will create (e.g. seeing through an object, clarifying the shape of two superimposed objects) - Ability to read a situation at a high level, and continue to read and adapt problem solving to situations as they change and develop (Alexander & Judy, 1988; de Jong & Ferguson-Hessler, 1996; Klein & Hoffman, 1993). For example, receiving new information from the use of an IEF, and then altering strategy (e.g. applying a complimentary IEF) based on the new information |
| Insufficient | - Hesitation and indecision (Lipshitz & Strauss, 1997) before and during the use of interface interactions, such as lengthy delays and extensive deliberation before selecting an image enhancement function - Propelled action or poorly thought through action (Hall, 2002), such as trial and error application of image enhancement functions |

**A.4 Screener Interaction Sub-Codes and Heuristics**

| **Sub-Code Category** | **Sub-Code** | **Example Heuristics** |
| --- | --- | --- |
| **Knowledge** | Perceptual | - Demonstrating knowledge about visual concepts and their meanings (Patterson et al., 2007). For example, explaining specific visual features of an object or characteristic during a discussion with another screener |
| Procedural | - Knowledge of how and when to perform an action (de Jong & Ferguson-Hessler, 1996), For example, knowing what screener interactions are available as procedures and having a general understanding of when they are suitable to being applied- Evidence of conditional reasoning and statement of simple production rules (if – then rules) (Anderson, 1982; Roda, 2011), such as stating “There is a liquid in this bag, can you remove it” |
| Strategic | - Integrated sequences of action (Schraw, 1998), such as an examination of an object followed by an immediate re-run request (different angle, shake, etc)- Identifying and facilitating learning situations (Ertmer & Newby, 1996), for example, asking for an object to be removed after discussing it with another screener for the purpose of learning its appearance- Identifying and executing the optimal solution (Gruber, 1989), such as successfully identifying an object after requesting a bag to be re-run at a specific angle- Adaptable actions and problem-solving process (Phye & Sanders, 1992), such as recognising an unfamiliar situation and applying a screener interaction strategy to overcome it |
| Situational | - Rich mental representation and understanding of situation (de Jong & Ferguson-Hessler, 1996; Eraut, 1990), demonstrated by an immediate comprehension of the on-screen image as a problem context and application of strategic screener interaction - Predictive inferences relating to the result of change caused by actions (Kirschner & Van Vilsteren, 1997; Salas et al., 2009), such as a screener explaining what they expect to see as they request a strategic screener interaction (e.g. re-run)- Ability to read a situation at a high level, and continue to read and adapt problem solving to situations as they change and develop (Alexander & Judy, 1988; de Jong & Ferguson-Hessler, 1996; Klein & Hoffman, 1993). For example, changing perspective on an object or area of interest as information is gained from strategic screener interactions. Also, adapting strategy to suit situational limitations, such as applying an interim strategy (e.g. initiating a re-run) when no searcher is available |
| Insufficient | - Verbalisations indicating uncertainty (‘um, ah’, ‘what is that?’)- Hesitation and indecision (Lipshitz & Strauss, 1997) before and during screener interactions, such as lengthy delay before requesting an action or difficulty articulating the problem situation while requesting an action- Action propelled by uncertainty (Hall, 2002), such as hastily deferring decision making without attempting to solve the problem |
| **Screener Interaction Type** | Re-Run | When a security screener interacts with another security screener for the purpose of requesting a bag be rescreened through the x-ray machine. Request for a re-run can involve specific instructions for actions to be carried out prior to the re-run. These include:- **separation:**when contents of the bag (e.g. cables, electronics) are physically removed from the bag resulting in a clearer on-screen image . For example, “can you take those cables out and re-run the bag”.- **shake:** when the bag is physically shaken to redistribute its contents (e.g. clumped objects at the bottom of the bag causing a dense area) resulting in a clearer on-screen image. For example, “can you give that a shake and then re-run it”.- **different angle:**when a bag is screened at a different angle (this can be specified precisely by the screener) to improve the on-screen view of a particular object or area in the bag. For example, “can you re-run this on its side, like this”. |
| Discussion | When a security screener interacts with another security screener for the purpose of discussing an object or area of the image. The exact topic of discussions can vary considerably, but they can be categorised based on a limited number of purposes. These include: *-* **Deferring decision-making:** when a security screener asks another security screener to identify the object on-screen, without providing their own judgement. For example, “what is that?”*-* **Clarifying information relating to an object:**when a security screener asks another security screener to clarify policy relating to an object (e.g. medications or liquids for a baby). For example, “are they allowed to take these fish oil capsules?”- **Confirming decision making:** when a security screener suggests an objects identity to another security screener and asks for it to be confirmed. For example, “I think that is a pair of tweezers. What do you think?” |
| Manual Search | When a security screener interacts with another security screener for the purpose of requesting a bag to be manually searched in order to determine the identity of an object that could not be identified on screen and obtain its identity. For example: “Can you get that out and take a look?”  |
| Threat Removal | When a security screener interacts with another security screener for the purpose of having a prohibited object removed. For example, requesting the removal of a LAG, sharp, other prohibited item that has been successfully identified on screen.  |

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