| | | | |
|---|---|---|---|
| **Fiscal Year:** | FY 2018 | **Task Last Updated:** | FY 09/26/2018 |
| **PI Name:** | McLaughlin, Anne Ph.D. | | |
| **Project Title:** | Creating a Taxonomy of Variables Affecting Cognitive Aid Design via an Investigation of Hybrid Aids | | |
| **Division Name:** | Human Research | | |
| **Program/Discipline:** | | | |
| **Program/Discipline--Element/Subdiscipline:** | HUMAN RESEARCH--Space Human Factors Engineering | | |
| **Joint Agency Name:** | | **TechPort:** | No |
| **Human Research Program Elements:** | (1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H) | | |
| **Human Research Program Risks:** | (1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture<br>(2) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures | | |
| **Space Biology Element:** | None | | |
| **Space Biology Cross-Element Discipline:** | None | | |
| **Space Biology Special Category:** | None | | |
| **PI Email:** | anne_mclaughlin@ncsu.edu | **Fax:** | FY |
| **PI Organization Type:** | UNIVERSITY | **Phone:** | 919-513-2434 |
| **Organization Name:** | North Carolina State University | | |
| **PI Address 1:** | Department of Psychology | | |
| **PI Address 2:** | Box 7650 | | |
| **PI Web Page:** | | | |
| **City:** | Raleigh | **State:** | NC |
| **Zip Code:** | 27695-7650 | **Congressional District:** | 4 |
| **Comments:** | | | |
| **Project Type:** | Ground | **Solicitation / Funding Source:** | 2015-16 HERO NNJ15ZSA001N-Crew Health (FLAGSHIP, NSBRI, OMNIBUS). Appendix A-Crew Health, Appendix B-NSBRI, Appendix C-Omnibus |
| **Start Date:** | 08/09/2016 | **End Date:** | 02/01/2019 |
| **No. of Post Docs:** | 0 | **No. of PhD Degrees:** | 1 |
| **No. of PhD Candidates:** | 1 | **No. of Master' Degrees:** | 1 |
| **No. of Master's Candidates:** | 0 | **No. of Bachelor's Degrees:** | 0 |
| **No. of Bachelor's Candidates:** | 1 | **Monitoring Center:** | NASA JSC |
| **Contact Monitor:** | Williams, Thomas | **Contact Phone:** | 281-483-8773 |
| **Contact Email:** | thomas.j.will1@nasa.gov | | |
| **Flight Program:** | | | |
| **Flight Assignment:** | NOTE: Extended to 2/1/2019 per NSSC information (Ed., 9/5/18)<br>NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17) | | |
| **Key Personnel Changes/Previous PI:** | June 2017 report: Dr. Aniko Sandor, the original co-Investigator, left her position at KBRWyle in late 2016. We have been working with substitute co-Is and currently are working with Vicky Byrne, a specialist in medical human factors, who is now listed as Co-Investigator. | | |
| **COI Name (Institution):** | Byrne, Vicky M.S. ( KBRWyle ) | | |
| **Grant/Contract No.:** | NNX16AP91G | | |
| **Performance Goal No.:** | | | |

**Performance Goal Text:**

**Task Description:**

This proposal addresses the NASA Research Announcement for Human Exploration Research Opportunities (HERO), NNJ15ZSA001N-FLAGSHIP Appendix A, Interactive Cognitive Aids. Onboard crewmembers, similarly to operators from other industries, complain about using current checklist-like procedures. Issues include procedures having too much or too little detail and poor usability. Due to these, mistakes still occur and time to accomplish procedures is misestimated. NASA crew presently use static paper or electronic “cue cards” (PDFs) and procedures that provide guidance on both nominal and off-nominal tasks. Existing tools may not account for the lack of recent training, may not be optimized for the task, may not be optimized for the number of users, and may not be resilient to resumption after interruption. A more interactive cognitive aid can overcome the limitations of these cue cards and procedures by matching task, individual, team structure, and environment.
This proposal addresses the Risk of Inadequate Critical Task Design of the Human Research Program (HRP), specifically the SHFE-TASK-02 gap: What model-based HF (human factors) Tools can assist with the design and evaluation of spacecraft systems and task procedures. A toolkit is needed to support dynamic task design, particularly for design by non-programmers who would be making the procedures. There exists no taxonomy of cognitive aid design and task type nor standards for interactive cognitive aids to drive development. A cognitive aid should provide guidance to support efficiency and success while minimizing cognitive workload, but it is not yet clear what attributes, such as adaptability, the aid should contain.

The proposal also addresses the HRP’s Risk of Performance Errors Due to Training Deficiencies, specifically the TRAIN-03 gap: We need to develop guidelines for effective onboard training systems that provide training traditionally assumed for pre-flight. (Previously: SHFE-TRAIN-03 - How can onboard training systems be designed to address Just in Time (JIT) and recurrent training needs for nominal and off nominal scenarios?). To contribute to the closure of this gap, the research proposed will investigate cognitive aids for non-expert operators.

Our goals in this proposal are two-fold: The first goal is to investigate a new form of cognitive aid that incorporates the beneficial attributes of static, adaptable, adaptive, and dynamic aids into a hybrid aid. We see the benefit of this hybrid aid to be:

1. a technology able to be immediately deployed (unlike augmented reality or other heavily technology-dependent advances),

2. a technology able to be used by non-programmers as they design aids for crewmembers (the audiences would be procedure designers and scientists creating procedures for in-flight experiments),

3. a form of aid that offers the beneficial attributes of a dynamic aid that responds to each step in a procedure with the security of a static or adaptable aid that does not require functioning sensors for performance.

We will iteratively design a prototype of a hybrid aid for medical equipment maintenance tasks, while at the same time building a library of tools to create similar aids for other procedures. Second, we will develop a taxonomy of cognitive aid design that considers the most important variables affecting performance with aids: user knowledge and experience, resources demanded by the task and sub-tasks, time pressure on performance, and the number of operators expected to interact with the aid.

**Rationale for HRP Directed Research:**

**Research Impact/Earth Benefits:**

The results of the proposed work will provide guidelines for the development of cognitive aids in any number of areas, including aviation, automobiles, manufacturing, nuclear power plants, and medical procedures. Reducing error rate in many of these circumstances can save lives. Reducing duration spent on the task could reduce costs. A system that is no longer cumbersome or distracting will encourage adherence, one of the major flaws of current procedures and checklists.

Progress June 2017 - August 2018
The project received a no-cost extension until February, 2019, to complete software iterations on the cognitive aid, dissemination of the experiment data, and completion of the taxonomy of variables involved in cognitive aid design.

The two Risks and Gaps addressed by this research were:

Risk of Inadequate Critical Task Design of the Human Research Program (HRP), specifically the SHFE-TASK-02 gap: What model-based HF Tools can assist with the design and evaluation of spacecraft systems and task procedures?

Risk of Performance Errors Due to Training Deficiencies, specifically the TRAIN-03 gap: We need to develop guidelines for effective onboard training systems that provide training traditionally assumed for pre-flight.

The results inform the Risk of Inadequate Critical Task Design by: 1) discovering the helpful tools and forms of flexibility that aid in procedure use, in our case via a hybrid cognitive aid, 2) informing on the effects of aid-modality as it conflicts or does not conflict with the modality of the task described by the procedure, 3) the functioning of cognitive aids when operators are under time pressure, and 4) the real-world use of cognitive aids when operators work in teams. The findings also gauged the impact of interruptions during procedures and recovery from errors. Regarding the Risk of Performance Errors due to Training Deficiencies, the findings demonstrated how novices perform a new task with just-in-time training offered by the procedure and how this training might be improved by the added experiences of other operators who used the procedure in the same environment.

In the last year we fully completed, analyzed, and wrote up Experiments 1 and 2, which served as the dissertation of Dr. John (Jojo) Sprufera. Research questions in these experiments included task-aid modality conflict and the tools provided in a hybrid cognitive aid. We collected pilot data and full data for Experiment 3 concerning team interactions with the cognitive aid and the effects of time pressure on aid use, with and without a second operator. We collected data for Experiment 4, regarding the best perspective (first person vs. third person) for media shown in the cognitive aid. Last, we developed a working aid prototype with the help of a research assistant in computer science based on our findings from these experiments. This working prototype was tested in a validation study at Johnson Space Center where 28 experienced participants interacted with the aid compared to a procedure not augmented with the cognition aids.

| | |
|---|---|
| **Task Progress:** | Summary of progress on Experiment 3: Participants and Materials and methods were similar to Experiment 1. Changes included: the ventilator setup task was divided into sections that were either performed under time pressure (using video and audio to mimic an emergency) and participants were randomly assigned to perform the setup task alone or in a team of two. Twenty participants operated alone and and forty in teams of two.<br><br>In general, the setup task was performed faster and more accurately by teams and faster (but less accurately) when under time pressure. Use of the cognitive aid was observed to be distributed among the team members, where one tended to take ownership of reading the aid while the other followed instruction. Negotiation of understanding of each step occurred frequently between team members.This finding points to the importance of an operator (either human or potentially part of the aid) providing directive instruction while the task is being performed by another. This keeps the operator engaged in the task.<br><br>Summary of progress on Experiment 4: When participants used the aid in Experiments 1, 2, and 3, we observed the benefits and difficulties our media augmentations provided. This prompted a new question that needed to be answered in design of the aid: from which perspective should video and picture augmentations be provided? A media visual taken from the first person perspective requires no mental rotation when the task is performed, while a third-person perspective requires mental rotation. We hypothesized that, under ideal conditions with highly able operators, the perspective of the media would have little effect on performance. However, when the task was highly spatial, difficult, and or complex, we expected perspective to have an effect, such that the addition of mental rotation would decrement performance. Similarly, when the operators were under high cognitive demand, as can occur with multi-tasking or interruptions, we expected perspective to have an effect.<br><br>To test these hypotheses, we again used the setup of a medical ventilator as our task and provided video instruction via a cognitive aid. This instruction was manipulated to show the first or third person perspective. Our participants were younger adults (18-28) with relatively high fluid abilities (as measured via tests of spatial ability) and older adults (65-75) with relatively lower fluid abilities. Such a sample allowed us to test the general hypothesis that the importance of perspective was linked to available mental resources. Participants were randomly assigned to a perspective condition. The full design contained two age groups and two perspective conditions. Errors (omission and commission) and completion times were collected.<br><br>Data were gathered in the spring and summer of 2018. Analyses are ongoing.<br><br>Software Products: The hybrid aid prototype was iteratively designed and tested during the validation study at Johnson Space Center.<br><br>The designs are the result of several iterations of usability testing of the hybrid-aid concept via the validation study. They are currently being implemented in software. |
| **Bibliography Type:** | Description: (Last Updated: 07/10/2023) |
| **Abstracts for Journals and Proceedings** | Sprufera JF, Pryor M, Byrne V, McLaughlin AC. "Sensory modal interaction while using a cognitive aid during an off-nominal complex medical task." Presented at APA2018, Meeting of the American Psychological Association, San Francisco, CA, August 9-12, 2018.<br>APA2018, Meeting of the American Psychological Association, San Francisco, CA, August 9-12, 2018. , Aug-2018 |
| **Abstracts for Journals and Proceedings** | Hicks WB, Pryor M, Greene A, Sprufera JF, Byrne V, McLaughlin AC. "Development of evidence-based guidelines for medical cognition aids." Presented at the 2018 International Space Station (ISS) Research and Development Conference, San Francisco, CA, July 23-26, 2018.<br>2018 International Space Station (ISS) Research and Development Conference, San Francisco, CA, July 23-26, 2018. , Jul-2018 |
| **Articles in Peer-reviewed Journals** | Hicks WB, Pryor M, Sprufera JF, Greene A, Byrne V, McLaughlin AC. "Time pressure and team dynamics: Contextual factors influencing performance when using a cognitive aid." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2018 Sep;62(1)):125-9. (62nd Annual Meeting of the Human Factors and Ergonomics Society, Philadelphia, Pennsylvania, October 1–5, 2018.) https://doi.org/10.1177/1541931218621029 , Sep-2018 |
| **Dissertations and Theses** | Sprufera JF. "Cognitive aid use during complex off-nominal tasks: Considerations of modality and additional functionality on performance." Dissertation, North Carolina State University, June 2018. , Jun-2018 |