ALIGNING FUNCTIONAL ANALYSIS PROCESSES WITH DESIGNERS' NATURAL COGNITIVE FLOW

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ABSTRACT

Engineering design in new product development is a constant battle between creativity and strict structure. As researchers look to optimize the process, each stage is placed under a microscope to put designers in the best position to develop better products for companies in a cost effective manner. One idea in improving product development is the concept of incorporating the Human-centered Design into functional analysis. However, critiques of these functional analysis methods cite an unnecessary amount of resources needed to invest in these steps, a restriction in creativity, and a high necessary level of effort from the design teams. The goal of this research will be to address these critiques by incorporating theories from cognitive research and Human-centered Design into the functional analysis process. This work will propose a new method aimed to improve the quality of the function model of the design space, increase the creativity freedom of the designers, and be accessible to engineering students and industry engineers alike.

Keywords: Design methods, Design cognition, User centred design

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1 INTRODUCTION

Creativity in engineering design has fuelled the world's technological growth for centuries. Classical engineering design processes are filled with rules and structures to protect design projects from falling off-track, especially when developing complex products (Ulman, 2008). These restrictions have the positive effect of creating a more repeatable process, but an adverse effect of potentially limiting creativity or creating a more cumbersome process. The engineering design process, at its base level, is a structured series of steps that engineers follow along on the path to developing a solution to a problem, as illustrated in Figure 1. In this context, the problem is a need that is being addressed with a solution produced through engineering design and will be referred to as the design problem. The first few three stages are focused around defining and developing the design space in preparation for the remainder of the design process. These preparatory stages have a large influence on the success of the future stages as they are developing the foundation upon the rest of the project is built. Functional analysis (FA) is a common technique to bridge from these preparatory stages to the design concept generation stage. Traditionally, engineering designers have approached this process in an inherently highly function-based frame of reference (She et al, 2022). In other words, the requirements and evaluation attached to the final solution were heavily based on the product action and less centered around users. If design engineers could incorporate a stronger consideration for users into the earlier stages of the design process, this could result in more complete prototypes in the first design cycle, and limit the amount of costly design overhauls. This research looks to improve upon currently available FA strategies by incorporating elements of Human-centered design (HCD) into these early design stages. More information on these topics in Section 2.1.

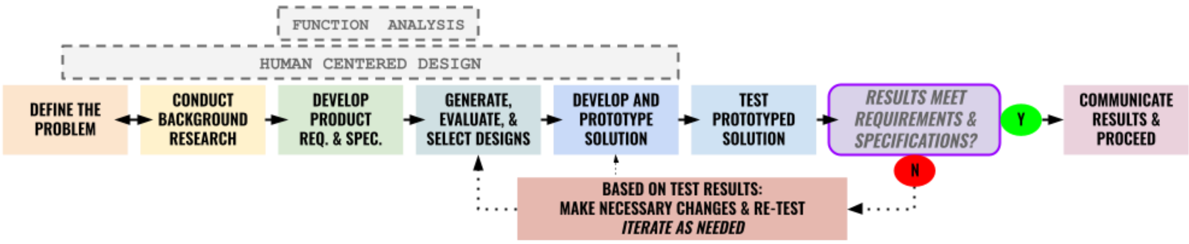

Figure 1. Engineering design process

Structured functional analysis design process, filled with rules and regulations, has been shown to have a negative impact on the designer's ability to be creative (Booth et al, 2015; Caldwell et al, 2012). These strict guidelines hinder the designer's ability to be creative and focus on developing a working solution. Additionally, inexperienced engineers that are not thoroughly versed in the design process and related terminologies may feel struggled in FA while seeing less value (Booth et al, 2015). Leveraging research findings in cognitive science, this manuscript proposes a streamlined method of functional analysis better aligned with natural information processing, in turn reducing cognitive barriers while improving creativity of the generated functional models, and adding flexibility to accommodate novice and experts. The validation plan is structured to test the effectiveness of the proposed strategy as the next research step.

2 BACKGROUND

To establish the foundation of the proposed method and validation study, Section 2 includes key aspects of research literatures from which the motivations and the proposed solution are built upon. This paper looks to incorporate ideas from (2.1) existing functional analysis methodologies, (2.2) human-centered design, and (2.3) cognitive science to develop a method to address and improve upon these issues.

2.1 Current methodologies in functional analysis and human-centered design

Functional analysis (FA) is used in product design to break down how a designed system will work with the intent to establish the most significant components that contribute to the greater functionality (Krupczak, 2010). The concept of incorporating HCD in product design is not new, but there has been more push in research to investigate the true benefits and increase the prevalence of these strategies (Chammas et al., 2015). It emphasizes helping engineers develop function models with a stronger

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correlation to the context of end user. With the strong adherence to function-based design processes, traditional FA methods included, users can often get put on the backburner to focus on later. Sometimes user testing occurs in later stages, during the testing stage as shown in Figure 1 from the introduction, but sometimes companies do not invest the resources to conduct user testing and focus purely on durability and function. For those that do, this may be the first point in the process where they will begin to gain a better understanding of how their users interact with the product and if the product is liked. If this discovery goes poorly, design teams may be forced to iterate back through the process again with a need for severe change (Knisely, and Vaughn-Cooke, 2022). Unlike iterating back through the process to fix small issues in a prototype design, re-designing around an entirely new user perspective can be wildly expensive if there is a large change in scope. To combat this, designers use several traditional FA methods and HCD strategies. One of the simplest FA models to use is the hierarchal functional decomposition tree. This decomposition begins with the primary purpose or function of the product being designed and is broken down into smaller subfunctions. An example is shown below in Figure 2.

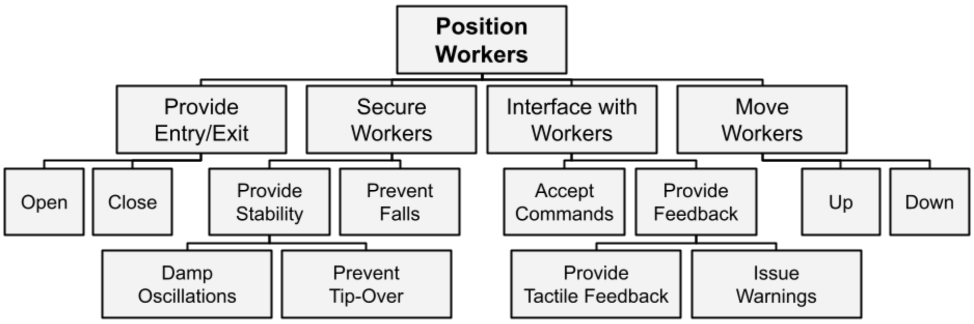

Figure 2: Example of function tree in context of articulating-boom construction lift

A more modern method, developed by Saurischian and their colleagues (2013), the function analysis diagram (FAD) model had been designed to better align with the natural way of working of engineers involving simultaneous thinking with function and structure. The method proposed in this work in Section 3.1 has similar goals to the FAD model, but differs in approach and could potentially be a simpler steppingstone method for novice engineers to learn and master before the more intricate FAD.
FA helps design engineers break down larger design problems into smaller, and more manageable, sub-functions (Pahl et al., 2007; Ulrich & Eppinger, 2012). With the ability to incorporate HCD elements into FA, designers can reap the benefits of both systematic and user-focused thinking. A method that heavily influenced the proposed solution later in this work was the function interaction model developed by Ramachandran (2011). This technique builds a model containing product functions, as well as user action, and product interactions within a single model. FIM includes active functions (product actions) and passive functions (user actions or interactions with other systems). Results comparing traditional function models and FIM (Caldwell et al, 2012) found that designers using the traditional function model generated more design concepts, but the quality of solutions from the FIM group was significantly better. With the results of increased quality in mind, the proposed solution later is inspired, in part, by FIM while also incorporating HCD elements such as User Workflows.
Previous work by She and her colleagues (2022) focused on embedding customer requirements into a user workflow to support novice engineers in functional analysis. A user workflow was defined as a typical path or a sequence of actions taken by target users through their use of a product or a system. Referencing this can aid design engineers through the process of FA when generating functions, and it also provides greater insight into the user experience. This work looks to incorporate the interaction analysis of FIM and the simplicity of user workflow in the proposed process flow in Section 3.1. An example of a user workflow from their study, without embedded requirements, is shown in Figure 3.

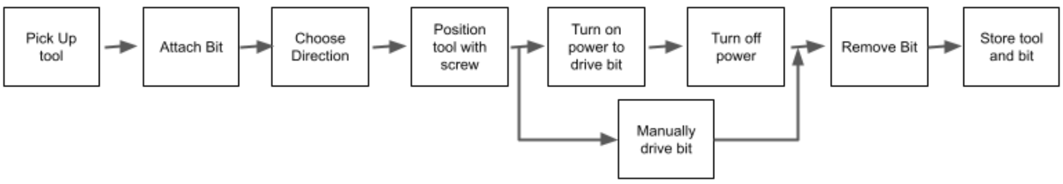

Figure 3: Example of user workflow in the context of a power screwdriver

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2.2 Critiques of functional analysis and human-centered design

As previously alluded to, FA enables designers to break a larger product goal into its basic functional components, then the primary focus can be designing for each of these smaller items and how they interact instead of attacking the entire problem. In theory, if completed correctly, these functions meshed will form a product that successfully meets the overall need. HCD emphasizes the importance of understanding target users effectively, aligning the product design with user actions, needs, and their environment (Poirson et al., 2007; She et al., 2022). It is very common in computer and software engineering fields due to their increasingly customer-facing nature (Caldwell et al., 2012; Gericke & Eisenbart, 2017), however it is less common in mechanical design spaces. The idea is that incorporating a user-centric approach earlier on in the design process can limit some of the need for expensive redesigns in future stages (Knisely & Vaughn-Cooke, 2022) and provide better overall products for consumers. Expanding on this concept when developing design methods, it is also important to consider the designers, as they are the users of the design methods themselves. While the methods may have proven benefits of improving the final product output, many of the shortcomings in FA and HCD strategies themselves impact the designers using them. These shortcomings are elaborated on in slightly more detail in Section 2.2, but the increased effort, restriction of creativity, and complexity of these strategies contribute to the issues designers have with these (Booth et al., 2015; Caldwell et al., 2012; Eckert et al., 2011) When designing methods, such as the one proposed in Section 3.1 of this paper, the designers need to be front and center. This section will look to investigate these issues and search for ideas to better align these methods with the natural processes of design.

It is becoming common in the research field to acknowledge the benefits of functional analysis. Such efforts seem to yield more complete product designs by allowing engineers to not only focus on designing small subfunctions but see how they integrate into the overall functionality of the product. These benefits come with a trade-off however, in that these methods are typically heavily structured, sometimes complicated, and draws a larger investment of time and resources into the early stages of the process which many in industry see as a negative.

In industry today, HCD is not very common in the early stages of the design process and some industry design engineers skip a structured functional analysis entirely. The latter of which has largely been attributed to the feeling of restraint and limited creativity from designers (Caldwell et al, 2012; Booth et al, 2015). The current state of functional analysis comes with many syntax rules and restrictions to consider along the way. The purpose of these rules is to create a more consistent and thorough process, ensuring that all product design specifications are covered in the scope. However, designers want to be creative, and they do not want to labor over rules and regulations early in the creative process. Studies have shown that these participants feel bogged down, at times, by the process, and the results they produce are often limited as well. (Caldwell et al, 2012; Knisely and Vaughn-Cooke, 2022) Additionally, these methods are challenging for inexperienced engineers to pick up. Students and early-career engineers that are not thoroughly versed in the design process and accompanying terminology may struggle through functional analysis. This hurdle appears to be the largest recurring theme in this space today; Balancing creativity and structure to find the maximum benefits of functional analysis and Human-centered Design. The proposed method looks to address this challenge and draws support from cognitive science research in Section 2.3.

2.3 Cognitive science and design thinking

Integrating theories from cognitive science research into design thinking are great strides in the field of design science (Strimel, 2014). Some work that could connect to some of the current shortcomings with functional analysis comes from research in cognitive psychology. This section will look to rationalize struggles related to functional analyses by deduction from cognitive research findings focused in three areas: (a) comparison of problem-solving processes in experts and novices, (b) gist and verbatim memory representations theorized by Valarie Reyna's Fuzzy-Trace Theory, and (c) the two modes of thinking, fast and slow, as described in Dual Process Theory.

Research conducted by cognitive psychologists Michilene Chi, Paul Feltovich, and Robert Glaser (1981) looks to explore the difference of approaches to problems, between experts and novices, in greater detail. In one of their studies, when given the same basic physics problems, participants were asked to group the problems together with other similar problems. They found that experts used deeper abstract physics principles to categorize these problems, whereas novices based their categorization on the problem's literal basic features. Responses from participants demonstrated how experts grouped

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problems based on the underlying physics principles that can be used to solve the problem, while novices highlighted physical attributes of the problem to compare solving processes. This difference in categorization demonstrates a distinct difference in understanding of these problems. As a result, the process of solving the problems that follows this initial analysis will likely take a very different path as well. In another study Chi, et al. attempted to analyze the path experts and novices would take to solve a problem by asking them to share their planned basic approach. In this they again found that experts used deeper abstract physics principles to approach the problems, and were able to concisely describe their approach. The results for the novices, were much less clear and their approach would either be a statement about a chain of processes or "detailed equation sets they would use." The different approaches to problem solving between experts and novices seems to stem from the depth of their understanding and could connect to their approaches to functional analysis as well.

A potentially relevant theory derived from research in Cognitive Psychology is Valerie F. Reyna's Fuzzy Trace-Theory (2012). This theory distinguishes between gist representations, meaning-based, and "superficial verbatim representations of information" (Reyna, 2012). Reyna claims that intuition produces meaning-based memory and reasoning which can increase as one matures into adulthood. She defines gist memory as memory of which the substance is "irrespective of exact words, numbers, or pictures" and is a mental representation encompassed by meaning. Where verbatim memory is representations based strongly on the exact words, numbers, or pictures relating to the information at hand. This can potentially connect back to the novice students studied in the work by Chi, et al. As this could relate to functional analysis, less experienced engineers may follow the process step-by-step as they were taught it, at first without gathering much meaning as to why. In contrast, those with more experience have gathered a greater gist-based understanding of the processes, and one can speculate that this allows experts to skip or quickly move through steps in the process they may deem irrelevant in certain contextual environments.

In cognition, dual-process theory proposes that human cognition is made up of two distinct styles of thinking; a mode that is fast, implicit, and natural; and another that is slow, controlled, but laborious. In his book Thinking, Fast and Slow, Daniel Kahneman (2011) discusses this model of human cognition. He presented dual process theory as two systems of thinking, where system 1 was fast and intuitive while system 2 was slow and tedious. Beyond the surface-level difference of speed between the two systems, it is theorized that the two systems of thinking play very different roles, and operate at different times, in the daily lives of humans. System 1 is believed to be instincts inside human cognition, and if the unconscious reactive responses from system 1 do not produce the predicted results system 2 takes over. A goal of the method to be proposed later in Section 3.1 will be to introduce less restrictions in the process, at least in the very early stages. If the method can successfully allow engineers to rely on a System 1 like mode of thinking, this could foster a more natural, fast, and creative design environment for design engineers. Without the need to dedicate mental resources to following the rules verbatim, designers can potentially be freer to utilize their intuitive creative ideas for functions. After this initial phase, the method can prompt designers to enter a more structured and calculated approach towards building the function model of the design space utilizing their System 2 mode of thinking.

3 PROPOSED STRATEGIES AND VALIDATION PLAN

Functional decomposition is a common practice taught in engineering curricula today. As a step in the early stages of the engineering design process, it can be helpful to break down more complex high-level issues into smaller manageable problems to design for. Incorporating the consideration of the user needs and interactions with the product into this process can lead to a more thorough and successful result. However, due to the increased investment of time and effort as well as the feeling of limited creativity, these processes have tangible limitations that have reduced their prevalence in practice. Further research and development are needed in the space of functional analysis and incorporating Human-centered Design in order to reach the theorized benefits. There is evidence to suggest, from industry interviews conducted by the author's team for a publication in progress, that the cumbersome structure of processes and rubrics blocked industry engineers and their companies to fit FA into their workflow naturally. This work will propose methods and ideas that hope to change this. The objective is to advance the development of improved design practices that are attractive to both industry and academia, and therefore eventually bridging this gap.

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This work will 1) propose strategies to overcome the challenges of functional decomposition as discussed in Section 2.2 (restricted creativity, complexity to novice engineers, and less valued by experienced engineers) based on Dual-Process Theory (Kahneman, 2011), Fuzzy Trace Theory (Reyna, 2012), the benefits of embedding HCD elements in FA (She et al, 2022) by referencing a process flow, and the function interaction model (Ramachandran, 2011). It will then 2) introduce a study validate the efficacy of the strategies, in a laboratory study, by comparing its effect on the design process and outcome to its status quo. It is hoped that, with the benefits of the proposed strategies, functional analysis could be more enticing to engineering students and experienced engineers alike. As a result, academia and industry design practices could potentially be more unified, students could be better prepared for industry jobs, and the design process could produce better products to be placed in the hands of societal consumers.

3.1 Proposed solution to improve functional analysis

The first goal was exploratory in nature. It intended to investigate issues with current function analysis processes, scrutinize gaps in related research, and integrate ideas from other research areas into functional analysis to explore potential improvements. As an outcome, a strategy is proposed to help designers overcome the aforementioned challenges of functional analysis with ideas built upon theories of human cognition, the benefits of human-centered design, and existing modelling strategies such as user workflows and the Function Interaction Model.

The benefits of functional analysis and human-centered design are covered in detail in Section 2.1, with the associated critiques and issues highlighted in Section 2.1. To help designers reap the maximum benefits of FA, while reducing some of the problems encountered along the way, the proposed solution should take the designer along a process that follows a more natural creative design cognitive flow while incorporating guiding elements of traditional functional analysis and human-centered design. The goal is to maximize creativity while providing checks and balances to assure a complete function model of the design space covering full functionality for the end user. The proposed process, termed Natural Cognitive Flow Functional Analysis (NCFFA) is briefly outlined in Figure 4 below:

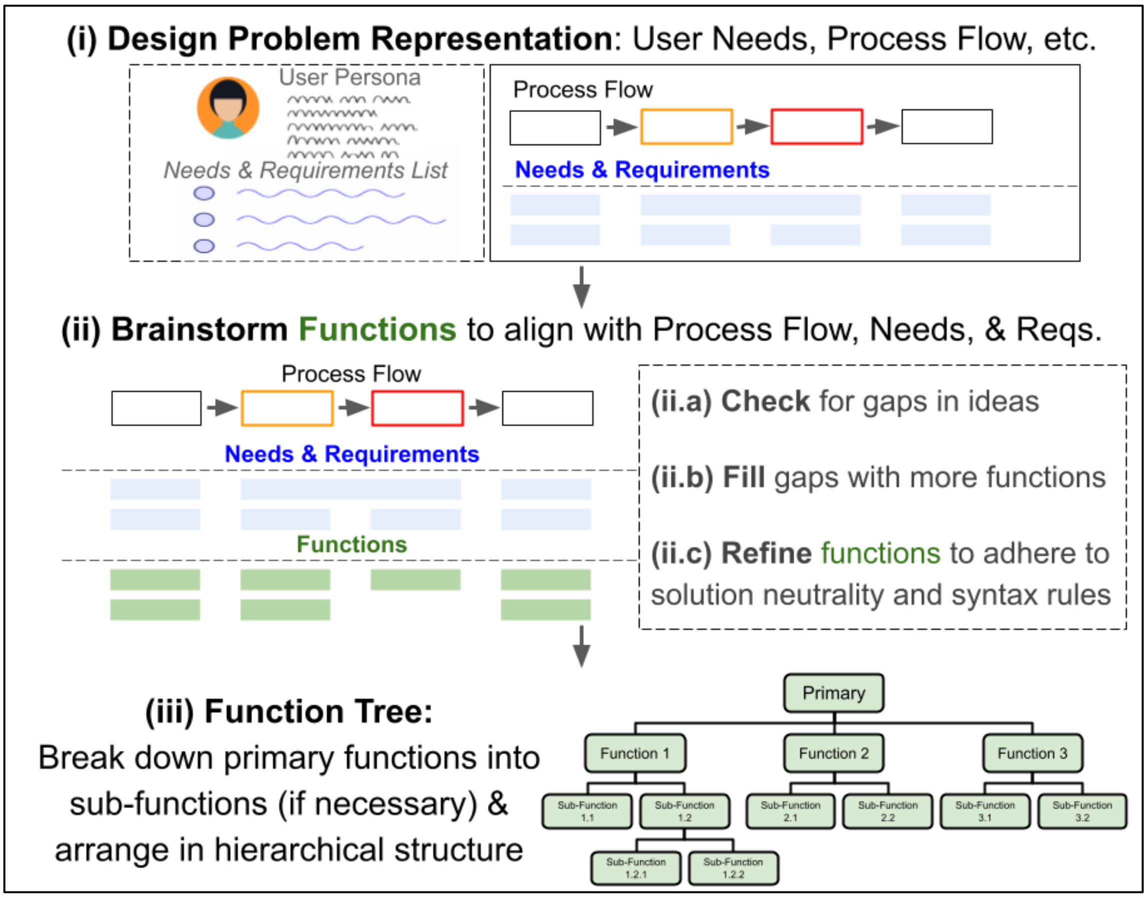

Figure 4. Proposed structure of natural cognitive flow functional analysis (NCFFA)

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In a typical design environment, as previously discussed, designers will start with some (i) representation of needs or requirements for the design. In consumer product design this typically can take the form of a basic requirements list for the end product. By tweaking the User Workflow and FIM, NCFFA proposes a Process Flow. In this context, a process flow incorporates a combination of product actions, user actions, and user-product interactions to display the full functional process flow the product will undergo. An example is shown below in Figure 5.

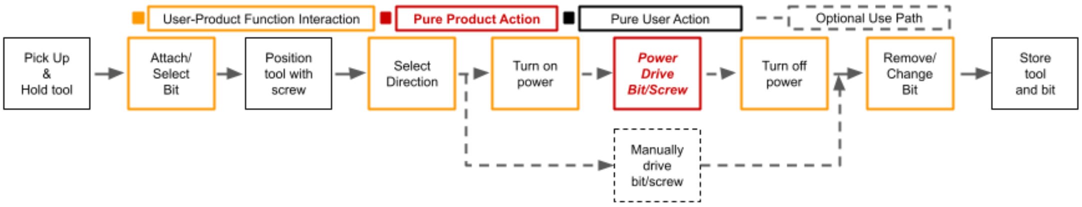

Figure 5. Example of a proposed process flow in the context of power drill

This example process flow is based off of the same design problem highlighted in Figure 3 when discussing user workflows. Visually a user workflow is very similar to this version of a proposed process flow. However, passive actions from FIM (Ramachandran, 2011) are split entirely into user actions and user actions that interact with a product function. All active product functions are included in this process flow (shown in red), along with user actions (in black), and user-product interactions (shown in orange). For a simple example like this there are much less product actions that stand alone, but in more complex design environments there may be many actions the product is performing behind the scenes without any interaction with the user. Some processes that involve interaction between the user and the product are tied directly to a product action, such the user interacting with the bit and the screwdriver, while others are simply the user activating some necessary functionality within the product, such as the direction selection and power on/off. It can be left to the discretion of the designer to decide how detailed the process flow must be to best assist them through the next stages.

In expert-level environments, such as industry design teams, this process flow in most cases will not be provided, and experts will produce this process flow as part of the initial problem definition stage. This activity should bode well for increasing the contextual understanding and empathy for the end users, but is potentially an additional complex step to analyze for novices.

Many previous functional analysis methods would immediately enter a structured decomposition step from this point. Critiques of this, outlined in more detail in Section 2.2, cited this strict structure and rules, such as syntax and solution neutrality, as a major struggle point. These factors hindered the designers' ability to think creatively and at times made this stage feel laborious. Connections were drawn, in Section 2.2, to theories in human cognition to partially rationalize some of these struggles from a different perspective. For the proposed process, the primary goal is to not halt the natural design flow. Motivated by cognitive and design research on brainstorming (Kannengiesser & Gero, 2019; Kahneman, 2011), NCFFA will deliberately separate the generation of ideas from the evaluation of ideas. In a (ii) brainstorming exercise the designer will generate functions as they reference the needs of the user and process flow without regard evaluating the functions based on syntax rules, solution neutrality, or how it fits in the larger structure of the product. By removing the designers from a structured process, that will likely engage a System 2 mode of thinking and prompting them to use their intuition in a brainstorming process, more likely to promote a mode of thinking closer to System 1, the designers could feel an increase in creativity and a decrease in perceived cognitive effort.

After brainstorming functions to address the user needs and each step in the process flow, NCFFA proposes that the designer now begins a more structured process to complete the functional decomposition of the design problem. The first few steps are to solidify and refine the brainstormed functions. The designer will (ii.a) verify that all aspects necessary for design functionality are properly met and (ii.b) iterate back to brainstorm more functions if any gaps are identified.

Moving forward with these initial primary function ideas in their current state could potentially open the designers to negative consequences such as design fixation (Jansson & Smith, 1991). With many other methods for function analysis, this consideration for rules (verb-noun syntax, solution-neutrality, etc.) was a part of the function generation exercise. In previous sections, this paper elaborated on the motivations for removing this restriction on the initial activity of generating functions to free-up the designer's creative intuition. When relying on quick intuition to develop ideas from the process flow

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and user needs, it could be natural to generate functions that are not solution neutral. For example, a certain functionality may be needed in a product to secure something; the proper function for this in a verb-noun and solution-neutral form would be "secure bit." However, it is sometimes more natural to envision solutions to how that item is secured, like "secure bit magnetically with magnet," but at this point the designer should be focusing on the why or what is needed, and not how. This function now only has one solution to secure the bit, with a magnet, and is restricting future design possibilities. Developing design ideas for each function is an activity for a later design stage, developing solutions. As a result, NCFFA includes this (ii.c) housekeeping step to refine the functions so they are in optimal form, verb-noun, and solution neutral, for the remainder of the design process.

As previously discussed, in section 2.1, with the next stage of function decomposition, the designer would now be advised to decompose the larger primary functions into smaller sub-functions that are simpler to design for. The most common strategy was to build a function tree, where the functions are organized in a hierarchical manner with primary functions towards the top and the sub-functions breaking off down below until the lowest level sub-functions can be met with a single and simple design. This strategy will be the suggestion (iii) method of developing a function model for NCFFA. These smaller designs are later integrated with other designs for sub-functions around it to make-up the larger functional design. Novices at times have found this a struggle, however in most previous cases they were tasked with generating these functions, focusing on the compositional rules, and building this tree at the same time. With this method, the functions have already been developed (ii), and refined (iii.c), to meet the requirements of the user and the suggested design rules of functional analysis. By completing this priming exercise, the novice engineers potentially will produce better and more complete function trees. Additionally, some expert engineers may elect to forgo this final step and rely on their experience to successfully develop and integrate designs, in future stages, for the primary functions of larger scope. Design experts using this technique will still have completed the earlier steps of this process, which incorporates Human-centered Design, but some of the additional heavily structured procedures have been trimmed. For inexperienced designers, separating these exercises will potentially place them in a better position to assemble this hierarchical function tree, break down sub-functions where needed, and focus on understanding interactions between certain functions.

To summarize, the proposed Natural Cognitive Flow Functional Analysis looks to acknowledge natural human cognition, relating to Dual-Process Theory, and place designers in environments at various stages of the design process that can take advantage of the characteristics of System 1 and System 2 modes of thinking. By limiting the rules and restrictions at the beginning of the process, hopefully the designer can feel free to explore intuitive and creative function ideas to address the needs of the end user. The goal is to limit the amount of time spent in a mode of thinking like System 2 in order to lessen the perceived cognitive load at this stage. After a freer function generation step, the designer should search for gaps in the generated functions and refine the functions to prepare them for future design steps. At this point, some experts may be ready to begin developing design solutions for these functions of larger scope. However, novices will be primed to enter a function decomposition task, that will allow these larger functions to be broken down into smaller sub-functions in a hierarchical function tree where the lowest level are sub-functions that can be satisfied with a simple design. This function design space will be passed to the next stage of the process where design solutions can begin to be developed and integrated together for a complete design that meets all the needs of the human end-user.

3.2 Proposed validation methodology

To investigate if the proposed Natural Cognitive Flow Functional Analysis (NCFFA) method effectively addresses the challenges specified above in Section 2.2 and fulfils the goals outlined in Section 3.1, an experiment with a case product will be conducted using undergraduate engineering students to represent novice engineers. A case product will be selected with a formidable amount of complexity, to be suitable for functional analysis, and be reasonably common so that the participants should be familiar with this product type. In this context, formidable complexity would mean a product that has enough intricacy that functional analysis is needed to break down the functionality, but not too complex so that the concepts in the activity would be too abstract for the participants or take too much of time to complete.

The proposed experiment would be a between-subject design by manipulating what functional analysis method to use: traditional vs. NCFFA. Both conditions will receive information that includes a user persona, list of user needs, and a process flow. The experimental condition will be prompted to use the NCFFA method and guided through the steps, while the control condition will be tasked to build a

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function model using the hierarchical function tree but still receive guidance through the control method to assure balanced circumstances.

The means of data collection for this study will primarily take on two forms: analysis of the completed function models from each participant and information collected from a post-activity survey completed by each participant. From these two areas, explicit quantitative and qualitative data will be extracted to capture characteristics of the participants' function model and their experience producing the model.

This method set out to help novice engineers develop a more complete function model. The goal is to capture this by evaluating the depth, breadth, and resultant coverage of the functional model of the design space. The function trees will be evaluated for the total unique functions in the model, the total levels of the model, and the average number of functions per level. In measuring the number of hierarchical levels in the function tree, the depth of the function model should be represented. Alongside this, measuring the number of functions across the width of each level of the function trees should establish a breadth dimension approximation. Coverage, on the other hand, will attempt to be captured by tying the functions generated by the participants directly to requirements provided and measuring how thoroughly the design space is covered.

Another goal was to improve designer creativity. Some more information regarding creativity will be collected as part of the post activity survey, however this study will collect a novelty measure that looks to capture a quantitative view of creativity directly from the function model. This metric will be calculated by compiling all the functions generated across the participants. The frequency, or number of repeated mentions, for each function will be counted. Those functions mentioned most frequently will receive a lower novelty score, while those mentioned least frequently will receive a higher value. Each function will have its own novelty score, and the mean novelty score of each function tree can be calculated and used for comparisons. These three measures each serve a different role. To start with familiarity, this will be a self-provided ranking of familiarity or comfort level with FA that will serve as a balancing variable. It is important to record this metric, because if one group has a higher mean prior familiarity with FA, this could skew the results as we focus on novices. Next is perceived effort, which is currently the only quantitative variable being utilized to compare the necessary effort to complete the design tasks between the two methods. Finally, to measure creativity, the post-activity survey will include a Flow State Scale (FSS) self-assessment (Yang et al., 2018). Literature indicates that this scale has been used to study creativity multiple times and that the scale is reliable (Yang et al., 2018). With these measures outlined above, this study should be able to capture data from which conclusions can be drawn about the efficacy of NCFFA in comparison to a traditional functional analysis method regarding an improved function model, an increase in creative freedom of the designers, and a decrease in effort necessary to complete the design tasks.

4 CONCLUSION

To summarize, the proposed Natural Cognitive Flow Functional Analysis looks to acknowledge natural human cognition, relating to Dual-Process Theory, and place designers in environments at various stages of the design process that can take advantage of the characteristics of System 1 and System 2 modes of thinking. By limiting the rules and restrictions at the beginning of the process, hopefully the designer can feel free to explore intuitive and creative function ideas to address the needs of the end user. The goal is to limit the amount of time spent in a mode of thinking similar to System 2 in order to lessen the perceived cognitive load at this stage. After a freer function generation step, the designer should search for gaps in the generated functions and refine the functions to prepare them for future design steps. At this point, some experts may be ready to begin developing design solutions for these functions of larger scope. However, novices will be primed to enter a function decomposition task, that will allow these larger functions to be broken down into smaller sub-functions in a hierarchical function tree where the lowest level are sub-functions that can be satisfied with a simple design. This function design space will be passed to the next stage of the process where design solutions can begin to be developed and integrated together for a complete design that meets all of the needs of the human end-user. There is potential for this method to lead to design fixation when used on more complex systems, but the target of this method is to provide a streamlined and flexible process that is easy for novices to learn but still applicable for industry expert applications.

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