Air Traffic Control for Your Brain:

Translating the Science of Executive Function Using a Simplifying Model

A FrameWorks Research Report

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INTRODUCTION

The research presented here was conducted by the FrameWorks Institute and sponsored by The Center on the Developing Child at Harvard University and is part of a larger body of research that seeks to advance more effective ways of communicating about the science of early childhood development and its policy implications. The research described in this report is part of a more specific and conceptually targeted study exploring the ways that Americans think about and make sense of the science of "executive function." The project then seeks to apply and employ this understanding to craft new tools and strategies that scientists and communications professionals can employ to translate the science of executive function and its relationship to the larger field of early child development. This report is situated firmly in this latter, prescriptive aspect of the task. The report identifies a *simplifying model* that, through a multi-method empirical testing and refinement process, has proven effective in creating, extending and expanding understandings of executive function that are consonant with the science of early child development.

From a scientific standpoint, the term *executive function* refers to a set of interrelated cognitive abilities that develop early in childhood — abilities that control and regulate a broad range of important life-skills, competencies and behaviors. In short, executive functions are the abilities that allow individuals to "function" and complete a wide variety of tasks. Executive functions are abilities that make a wide range of critical skills possible — including attention, memory and motor skills. These skills are employed in the performance of almost every task we carry out and, when the development of these skills is muted in childhood, it can greatly impair successful adaptation, flexibility and performance in real-life situations far into adulthood. While scientists in the area of early childhood development understand the critical importance of proper development of executive function abilities, a notion of this concept and its constituent skills is largely absent from both the public consciousness and the policy debates around the material needs of young children. To make this abstract concept more palatable to these audiences, FrameWorks has deployed an extensive array of research methods dedicated to bringing the *science of communications* to the task of translating the *science of executive function*. All in all, a total of more than 2,050 informants were exposed to various versions of the models across methods.

Simplifying models are metaphorically based frame cues that change the fundamental ways people understand what issues are "about." They are, therefore, useful ingredients in shifting and expanding the processing and interpretational frameworks that people have access to and can employ in interpreting information. By fortifying understandings of complex phenomena like early brain development and, in this case, executive function, simplifying models can give Americans more access to the science of child development, thereby predisposing them to see child well-being and development as a public issue that is amenable to and dependent upon sound public policy.

Following FrameWorks' multi-disciplinary approach of Strategic Frame Analysis™,[i] we unpack and distill the science of executive function. We also focus on how Americans' understandings of the components and concepts of this science are shaped by a shared set of assumptions and understandings — what anthropologists call "cultural models."[ii] These shared assumptions are what allow individuals to navigate their social worlds. However, cultural models can also play a

more restrictive role, shaping available interpretations and making some messages "easier to think" than others.[iii]

FrameWorks research has shown that the existing dominant cultural models associated with child development restrict the ability of Americans to understand the science of executive function[iv] — what it is, why it is important, where it comes from, and how the presence or absence of these specific socio-emotional and cognitive skills impacts the lives of individuals in more long-term and general ways.[v] Therefore, these shared cultural understandings make many of the messages of scientific experts, child advocates and policy reformers decidedly "hard to think." The result can be thought of as a problem of translation.

The research described in the following report shows that one simplifying model, based on the metaphor of *Air Traffic Control,* was more successful than 12 other candidate models tested with respect to the objectives mentioned above. This simplifying model can play an important role in improving understanding of the science of executive function and more generally contribute to the ability of scientists and advocates to communicate about early child development. Specifically, it establishes what executive function is, why it is an important developmental concept, and how children develop this foundational skill set.

It is important to note, however, that even the best simplifying models cannot accomplish everything that needs to be done in reframing a complex issue. Other frame elements — Values, Messengers, Visuals, Tone, Causal Chains, etc. — need to be tasked with addressing other routine mis-directions in thinking. Toward that end, this report is one in a series of explorations designed to identify effective elements of an always evolving frame around early child development.

In this report, we briefly discuss what a simplifying model is and why the design and application of this reframing tool is essential in creating more-effective communications about early child development in general and executive function in particular. We then discuss the process by which FrameWorks' researchers identified, developed and empirically tested the power of one specific simplifying model, chosen from a long list of other candidate models, in broadening public understanding of the concept of executive function and the importance of this concept within the broader domain of early child development. We conclude with a discussion of how this simplifying model can be applied in communication and science translation efforts.

What is a simplifying model?

A simplifying model can be thought of as a bridge between expert and public understandings — a metaphor that presents a concept in a way that the public can readily deploy to make sense of new information. More specifically, FrameWorks defines a simplifying model as a research-driven, empirically tested metaphor that captures and distills a concept by using an explanatory framework that fits in with the public's existing patterns of assumptions and understandings (cultural models).[vi] A simplifying model renders a complex problem as a simpler analogy or metaphor. By pulling out salient features of the problem and mapping them in terms of more concrete, immediate, everyday objects, events or processes, the model helps people organize information into a clear picture in their heads. This concretization has the potential to enhance understanding and make people more effective consumers of science media and ultimately better situated to think about how policy impacts social issues, like early child development, education

and child mental health.

On the basis of this theoretical perspective, FrameWorks has built a robust, reliable sense of what an effective simplifying model looks like and how it behaves.[vii] An effective simplifying model:

(1) improves *understanding* of how a given phenomenon works;

(2) creates more *robust, detailed and coherent discussions* of the given target concept (i.e., executive function);

(3) is able to be *applied* to thinking about how to solve or improve a situation;

(4) *inoculates* against existing dominant unproductive default patterns of thinking normally applied to understand the issue;

(5) is highly *communicable* — moving and spreading easily between individuals without major breakdowns in key concepts; and finally,

(6) is *self-correcting*. In other words, when a breakdown in thinking does occur, people using the model can re-deploy it in its original form, where it is able, once again, to clarify key aspects of the issue.

Why executive function needs a simplifying model

It is a fairly common feature of American life that the public rarely understands the mechanisms, processes or contexts that undergird social or scientific issues.[viii] As a result, scientists and advocates seeking to advance public policy solutions to issues like early child development face an uphill challenge. FrameWorks has developed a way of identifying, testing and refining simplifying models to "fill in" elements missing from the public's current understanding and patterns of thinking about scientific and social phenomena. This process begins with the identification of gaps between the public's understandings on the one hand, and those of experts on the other.

On the topic of executive function, in particular, FrameWorks research has located several key gaps in understanding.[ix]

Expert-Public Gap #1: What is executive function, and what are foundational skills and abilities that children acquire during development?

The most glaring gap between expert and public understandings is the fundamentally different set of skills and abilities that these groups see as the primary outcomes of child development. In FrameWorks' earlier cultural models interviews on executive function, conducted with average but civically engaged Americans, informants assumed that responsibility, communication and self-confidence comprised the most fundamental skills that children "get from development."[x] On the other hand, the experts interviewed emphasized the basic, foundational nature of inhibitory control, working memory and cognitive flexibility — the three specific skills that comprise the concept of executive function. Furthermore, when literal, but non-scientific, explanations of executive function and its component skills were offered to informants, they interpreted and discussed these skills using their default understandings of what skills and

abilities are truly important. In so doing, they attributed moral characteristics to executive function skills — translating the skills to conform to certain assumptions about what skills and abilities children really need. For example, informants perceived skills like inhibitory control and problem solving to be "all about respect and knowing right from wrong."

Expert-Public Gap #2: Why executive function skills matter

The difference between average citizens and scientists in thinking about what foundational skills and abilities are also structured a very different understanding about the relative importance of skills and abilities. Scientists positioned executive function skills as the foundation for more general functioning both during early child development and more generally from a life-course perspective. On the other hand, when members of the public were asked specifically about the importance of the skills that comprise executive function, they saw these abilities as less important than morally- and discipline-based characteristics, such as being kind, respecting ones elders and "learning the rules."

Expert-Public Gap #3: Process of acquisition

The earlier interviews also suggested that lay informants lacked models through which to understand *how* children acquire skills and competencies. When they did try to explain a process of acquisition, they asserted that the acquisition of basic skills "just happens," "like osmosis," or that "something [happens] with their brain and it makes them … I don't even know, but anyway, it's good for them." In short, acquisition was poorly understood. Experts, on the other hand, had a well-formed explanation of how basic skills develop — through processes like modeling and scaffolding.

Bridging these three gaps with simplifying models has the potential to bring expert explanations and understandings in line with public thinking. Literature on the use and effect of metaphor in cognitive processes and meaning-making strongly suggests that by providing the right image and drawing upon information already in people's everyday understanding of the world, scientists and advocates can create dramatically different public understandings — in this case, about what executive function is, why it matters and how it develops.[xi]

Employing the results of earlier qualitative research and cultural models theory more generally, the FrameWorks research team conceived of the work that an executive function simplifying model must do in the following way[xii,xiii]:

> a. The simplifying model must be understandable.
>
> b. The simplifying model has to convey an understanding of the constituent components of executive function: working memory, inhibitory control and cognitive flexibility.
>
> c. The simplifying model has to concretize the importance of these skills, both in the developmental process and in life more generally.
>
> d. The simplifying model has to help people gain an appreciation for the processes through which these skills are developed and honed — in short, that they "don't just happen," but instead require that a child actively engages in activities in which these skills are recruited and practiced.

e. The simplifying model needs to encourage an appreciation that "early matters" — that the development of executive function is a key part of *early* child development that shapes and determines a wide range of immediate and more long-term outcomes.

EXECUTIVE SUMMARY

- FrameWorks' multiple-method research process showed that the simplifying model of Air Traffic Control is highly effective as a tool for translating the science and communicating its importance to non-scientific audiences.

- The Air Traffic Control metaphor performed well in on-the-street interviews, where it was effective in structuring conversation around the importance of coordinating mental processes, managing and filtering distractions and shifting attention productively between tasks.

- These interviews also showed that the model was effective at clarifying that executive function skills are brain- rather than morally-based and that these skills are influenced by a wide range of factors. The model also facilitated an appreciation for how these skills develop — through practice and participation in certain types of tasks.

- The Air Traffic Control simplifying model also did well in a quantitative experiment where it was shown to be highly understandable and easily and effectively applied to thinking about executive function.

   o Results from another qualitative method (Persistence Trials) also showed that the Air Traffic Control metaphor was applicable in helping people understand what executive function is; focusing people's attention on behavior, attention and memory control; filtering; prioritization; switching gears; and organizing and evaluating multiple streams of information.

   o The model helped participants understand why executive function is an important developmental concept; that it is a foundational set of skills that shape learning as well as life outcomes, according to informants in these Trials .

   o Trials revealed that Air Traffic Control inoculated against a wide range of unproductive default patterns of thinking including: Mentalism, the Family Bubble, Default Development, Moral Competencies, Passive Children and Individualist Thinking.

   o The model further has the ability to self-correct and is highly communicable between individuals, as was evident in observations of multi-generation transmission

- In order to realize its full utility in communicating the science of executive function, applications of the Air Traffic Control simplifying model must be explicit about a set of skills and abilities that develop early. Applications of the metaphor must also contain the idea that these skills are rooted in the brain, that they improve with practice and training, and that they are necessary for full functioning. Without these crucial aspects of the simplifying model, the metaphorical power and potential will not be fully realized.

METHODS: HOW SIMPLIFYING MODELS ARE IDENTIFIED AND TESTED

FrameWorks has developed a multi-method process to systematically develop and empirically test simplifying models. These methods are summarized below and described in greater detail in the Appendix.

Phase 1: Mapping the Gaps

FrameWorks' research team first conducts two types of interviews, *cultural model interviews* and *expert interviews*. Cultural model interviews are conducted with members of the general public and are designed to gather data that, through qualitative analysis, reveal the underlying patterns of assumptions — or cultural models — that members of the public apply in processing information on a given topic. Expert interviews are conducted with researchers, advocates and practitioners who possess an "expert" or technical understanding of the given phenomenon. These interviews are designed to elicit the expert understanding of the issue. Comparing the data gathered from these two types of interviews reveals the gaps that exist between how experts and average Americans understand and approach issues.

Phase 2: Designing Simplifying Models

FrameWorks' research team then analyzes transcripts of the interviews conducted in Phase 1 to generate a list of metaphor categories that capture salient elements of the expert understanding. This process draws from the fields of cognitive linguistics and psychological anthropology — specifically ideas related to the cognitive function of metaphor and symbols in the process of meaning making.[xiv] The result of the design process is a list of both metaphor categories (e.g., "orchestrating," "programming") and multiple candidate simplifying models in each category ("the conductor effect," "the computer effect"). The initial simplifying models generated are listed in the Appendix.

Phase 3: Testing Simplifying Models

Test I: On-the-Street Interviews

On-the-street interviews provide an opportunity to gather data on the effectiveness of candidate simplifying models. These interviews examine which models as well as which specific elements of the models are functioning well and which are less successful at shifting perspectives and improving understanding.

Test II: Quantitative Experimental Research

Using the results from on-the-street interviews to guide the revising and refining of existing iterations, FrameWorks designed a large-scale quantitative survey to test and demonstrate the varying efficacy of the simplifying models with statistical accuracy. The survey was conducted online with 2,000 participants who were drawn from a nationally representative panel.

The experiment measured three things: the general understandability of the metaphor (understanding), the participant's assessment of its appropriateness as a way to think about skills and abilities that children need (aptness), and each model's efficacy in structuring understandings of what executive function is, why these skills are important and how they are

acquired (application). These three measures were aggregated into an Overall Effectiveness score for each model. Air Traffic Control achieved the highest Overall Effectiveness score and was brought into the next phase of testing.

Test III: Persistence Trials[xv]

Based on the results of the quantitative experiment described above, the Air Traffic Control simplifying model was brought into Persistence Trials in Phoenix, Ariz., and Boston, Mass. In this phase of research, three Trials were conducted with a total of 18 participants. Participants were recruited on the basis of their involvement in their communities, and to assure variation in gender, race/ethnicity, education level, occupation, community involvement and self-reported political affiliation.

Persistence Trials are a qualitative method that mimics the game of telephone and has pairs of participants pass, or transmit, the simplifying model to other pairs of participants. Persistence Trials give us opportunities to see how the participants react to and use the model, how and how well the model travels and "persists" as it is passed between individuals, what parts of it are "sticky," and how it appears to change participant thinking on the target issue. The design of these sessions also allows researchers to observe several types of interactions (e.g., alone with each other, alone with the moderator, with the moderator and a new pair), which provides valuable insight into how the model is articulated and its thinkability.

Analysis of these data facilitated a detailed look at the specific communication advantages and challenges inherent in the model, and ultimately confirmed its effectiveness. These data were also used to make final refinements to the iteration, or instantiation, of the simplifying model to address specific issues and maximize its effectiveness.

RESULTS: AN EFFECTIVE SIMPLIFYING MODEL FOR EXECUTIVE FUNCTION

Employing the research process outlined above, FrameWorks' research team identified, refined and empirically tested four broad simplifying model categories and a total of 12 iterations across those categories. One of these simplifying models emerged as most effective in countering other dominant patterns of thinking about skills and abilities and introducing new ways for people to think about the science of executive function: *Air Traffic Control*.

The iteration of this model used in testing (but which was later modified, and appears in its modified version at the end of this document) was as follows:

Air Traffic Control

> *Children's ability to focus and pay attention is like Air Traffic Control at a busy airport. Some planes have to land and others have to take off at the same time, but there's only so much room on the ground and in the air. The mechanism that acts as Air Traffic Control is called executive function. It regulates the flow of information and the focus on tasks, creates mental priorities and avoids collisions, and keeps the system flexible and on time. In children, this mechanism needs to be actively geared up as early as possible.*

What Air Traffic Control Contributes to Science Translation and Public Understanding

I. General Effects. The results of on-the-street interviews illustrate the general communications characteristics of the larger category from which Air Traffic Control draws its clarifying and concretizing power. Models within the "Orchestrating" category were effective in focusing thinking and conversation on the role and importance of *coordinating* mental processes, filtering distractions and "switching gears." Based on patterns in their discussions, informants exposed to these models appeared to be able to see this fundamental coordination feature as a *brain-based skill* that children must develop.

> I guess learning to combine the skills into one unit instead of having separate skills that can clash with each other perhaps, or even just not work as well together. So you need to make sure that everything runs smoothly and that takes practice.
>
> Participant in On-The-Street Interviews

> As far as the orchestra, it's like the different areas of the brain. I don't know the exact, you know, differences in the areas of the brain, but they each have their own area; your memory, you know, like the trumpets, or the horns, and then they actually have to listen, and work together, and focus on the thing at hand.
>
> Participant in On-The-Street Interviews

The Orchestrating category from which Air Traffic Control was derived also appeared to help informants realize the importance of a wider set of factors — people and places — in shaping the process through which children develop executive function. This helped to fill in the process, or "how does it work," piece of the understanding.

These orchestration metaphors also structured discussions about *how* skills like coordination and inhibition develop — that they require *practice and training*.

> You start young, and you add on, and adding on and it's through repetition. It's developmental. It's [the simplifying model] saying that you start by teaching young, and showing over and over until they get it, and then moving up to something else, and over and over you develop those skills …
>
> Participant in On-The-Street Interviews

> The caddy is a metaphor for the way the brain trains itself with frequency of use, and over time, it gets better. And it must be exercised in order to achieve excellence.
>
> Participant in On-The-Street Interviews

> For the child to get those skills they have to be able to focus. They need practice, games, and over time with a lot of frequency, they perfect their game. The more they use the skills, the more they participate, the more they get the base capacity to analyze. That's how I can relate those skills to the human brain as it develops.
>
> Participant in On-The-Street Interviews

However, despite the otherwise promising effects discussed above, both the iterations of the larger Orchestrating category that were tested in on-the-street interviews (orchestra conductor and caddy) suffered from a common problem. In several cases the metaphors led to discussions about a child's need for a *person* to coordinate activities and attention. In short, a conductor or a caddy was assumed by many to represent the *parent*. Once informants made this interpretation, they predictably began discussing how "parents are really all that matters" and, therefore, that the best way to improve the skills and abilities of children is to focus on improving the way that parents parent. This confusion activates a dominant cultural model that the simplifying model was specifically designed to avoid — referred to elsewhere as "the family bubble."[xvi]

> So it means that, if the conductor is conducting in a calm and loving way, then maybe other people would respond in a good way depending on what he portrays, or she portrays as the head of that.
>
> Participant in On-The-Street Interviews

> My understanding is that what you're saying is that you have to have a guide for the child — someone who disciplines them in how to act and behave.
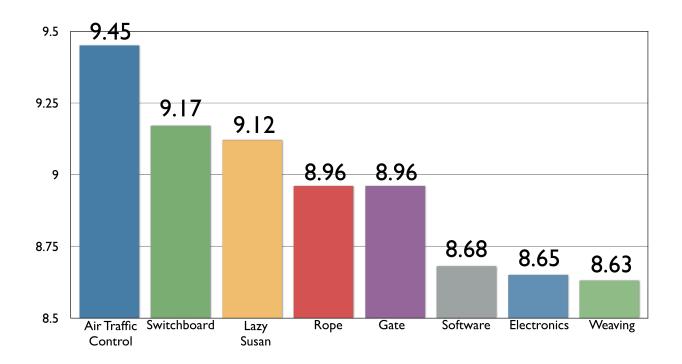>
> Participant in On-The-Street Interviews

The models that invoked a person as the agent of control (e.g., conductor, caddy) activated dominant cultural models through which informants viewed parents as the sole vector of children's development and the home as the only consequential site in which child development occurs. Further stages of the simplifying models research process moved to specifically test whether alternative iterations of this broader category of Orchestrating could use the effective aspects of this metaphor category without incurring the unproductive tendencies discussed above.

II. Evidence from the Quantitative Experiment. The quantitative experiment provided statistical evidence for the effectiveness of the Air Traffic Control metaphor. Results from the experiment indicated that the idea was highly understandable; easily and successfully applied to thinking about skills and abilities that comprise executive function, why these skills are important and how they are acquired; structured an understanding in which participants viewed issues within this domain as being "solvable"; and inoculated against the default dominant models that participants implicitly bring to bear on this topic.

The Overall Effectiveness scores (an aggregate of the more specific outcome measures of *understanding, application and aptness*[xvii]) for the models tested are presented in Figure 1.

Figure 1: Overall Effectiveness

Based on these results, the Air Traffic Control model was further refined and brought forward into Persistence Trials, where its more specific strategic advantages were explored.

III. Specific Strategic Communication Advantages. Persistence Trials revealed the following specific advantages of the Air Traffic Control simplifying model:

Application. Persistence Trials showed that the Air Traffic Control metaphor was applied in the following ways:

Understanding what executive function is
The Air Traffic Control model structured robust discussions of what are important skills for children to develop and provided an understanding of what executive function is. It is interesting to note that specific skills that participants drew from the idea of Air Traffic Control were highly consonant with those described by scientists as the components of executive function. [xviii] Below is a discussion of the specific components that informants saw as constituent elements of Air Traffic Control.

1. **Attention and memory control:** Participants explained that controlling attention and memory and directing focus were key parts of Air Traffic Control; through the

comparison, these skills were seen as key dimensions of the concept of executive function.

2. **Filtering:** Talking about the metaphor, participants recognized that executive function skills are like Air Traffic Control in that both mechanisms require the ability to ignore (or, as participants said, "filter") competing demands on a person's attention. Participants talked at length about the cacophony of life and its multiple, frequently dissonant demands on attention. Participants used Air Traffic Control to talk about the necessity of developing a skill to actively filter and manage these attentional inundations.

> I think it's [the Air Traffic Control metaphor] pretty much right on. Being able to focus on the task at hand is important, and today it's very easy to get diverted off on something over here. As a child if you're not taught those skills of how to take and prioritize and filter through what is really meaningful — I think you're going to have a severe problem and it might lead you to understand why some kids are going have a plane crash or what have you.
>
> Participant in Persistence Trial

3. **Prioritization/ordering:** The Air Traffic Control simplifying model was successful at conveying the concept of *prioritization*. In these discussions, brains, like available space on the ground and in the air for planes, are limited in the amount of information that they can input and process — in short, participants discussed the fact that children have limited mental airspace. Participants explained that with *limited* airspace and *unlimited* possible streams of incoming information, prioritization was central to the ability to focus and for the completion of tasks. Many participants went on to discuss how these prioritization skills are foundational in "planning," and that they therefore figure prominently in "almost everything we do at all levels" — from seemingly insignificant tasks like, as one participants said, "putting something in your backpack," to more complex things like problem solving and negotiating social situations.

> Obviously it's not in the same category as the Air Traffic Control, because there aren't hundreds of lives at stake at all times, but in the way air traffic is ordered, you have to have specific runways for different things, and kids learn how to sort things out in their mind.
>
> Participant in Persistence Trial

> I'm not saying it's [executive function] something where you have on blinders, and you're just going forward, forward, and just following the carrot. It's more like something where you can make choices and decisions as to how you want to do certain things. You're learning how to prioritize and how to organize things that you need to function. You're lining up the planes, so to speak, in the way that you want them to land, so that you can do what you need to do.
>
> Participant in Persistence Trial

4. **Switching gears:** Air Traffic Control also structured an understanding of the concept of cognitive flexibility — which participants referred to as the ability to "switch gears." Participants explained that Air Traffic Control is centrally about having the ability to change and deviate from plans and make on-the-fly judgments and adjustments. Participants connected these skills in the source domain (Air Traffic Control) with adjustments and flexibilities in planning and decision-making that children need to be able to make in their daily lives. The discussions about executive function following exposure to the Air Traffic Control metaphor frequently focused on the fact that sometimes "things don't go as planned" and that children (and adults) must be able switch gears and respond flexibly to accomplish goals.

> That's what we're talking about. Children are figuring out how to focus on the task that they're trying to do, and ignore other distractions, and get their goals accomplished, and what they're *intending* to do. This whole process is figuring that out in a way that they can get things done. And if the wind's blowing from one direction, the planes can't land that way, so you have to change it around and they have to come in a different runway. It's all about problem solving.

> Participant in Persistence Trial

5. **Evaluating and managing multiple sources of information:** Participants used the Air Traffic Control metaphor frequently and effectively in describing a composite set of skills that encapsulated all of the constituent elements described above. They talked about the need to be able to process, sort, manage, remember, mentally organize, assess and use information from a variety of sources in making decisions and modifying plans. This package of skills brings together the constituent components that scientists attribute to the concept of executive function.

> Well, in terms of the Air Traffic Control, you have to be able to sort out what is extremely relevant to your task at hand so you don't have a crash of the airplanes or a collision of the airplanes and in that way it's a good analogy to how children have to be able to process and sort through information. I think it plays well into what happens if we're paying too much attention to the planes that are out over, you know, uh … Patungsee, and we're not really looking at what's happening here. But we also have to keep our eye on the big picture — what planes are en route, what's leaving and where are they going, and be able to pass off the information to others.

> Participant in Persistence Trial

The importance of executive function
Having the idea of Air Traffic Control to work with and relate to the concept of executive function clarified the *importance* of the constituent components discussed above. Earlier research found that without an alternative way of thinking — such as a simplifying model — Americans do not place importance on the skills that comprise executive function. Rather, they consider the primary outcomes of early child development to be a set of moral characteristics (e.g., being caring, kind and respectful).[xix] The specific ways in which participants used the Air Traffic Control model to discuss *the importance* of executive function are presented below.

1. **Can't do one without the other:** After being exposed to the idea of Air Traffic Control, participants employed the discursive and logical rhetoric of "can't do one without the other" to talk about the importance of executive function. Participants explained that without these skills you simply "can't get anything done," and that these skills aren't narrow, but rather are "about life."

> If one child has this Air Traffic Control and the other one doesn't, their ability to handle and to think and form conversations and decisions later on down the road will be impaired. Because if they don't have the ability to dialogue and to learn and sift through different amounts of information and formulate an opinion of their own, taking on the different inputs of information and being able to assemble a complete picture, well …
>
> Participant in Persistence Trial

2. **"You need this stuff to learn":** After being exposed to the idea of Air Traffic Control, participants identified and discussed how executive function is indispensible in a child's ability *to learn*. Specifically, informants discussed how the ability to control both attention and distractions, and hold and work with information in mind, were critical learning skills.

> To me Air Traffic Control is about being in control and focused. You can't be out of control as a child and expect to learn. If you are going in a hundred different directions, and can't focus, I think you have a more difficult time learning.
>
> Participant in Persistence Trial

3. **The need to manage finite mental airspace:** As discussed above, the Air Traffic Control metaphor led to frequent discussions of the fact that children have limited mental airspace — that attentional resources and other cognitive capacities are finite. This realization led to a powerful conclusion about the importance of executive function skills. Participants reasoned that these skills are key in controlling and managing what comes in and goes out; at any one time, a child is able to focus limited attention on chosen tasks and inhibit distractions. In short, the metaphor was highly effective at instilling a sense of finite space and resources and, therefore, reiterated the necessity for prioritization and filtering functions. These became understood very clearly as key aspects of the concept of executive function when it was compared to Air Traffic Control.

> I use the relation of a tube of toilet paper. You're stuffing tissues into that toilet paper roll and you can only fit so many tissues into that toilet paper roll before they start flowing out the other side. It's the same way our brain handles different concepts and thoughts.
>
> Participant in Persistence Trial

Developing executive function

In addition to its ability to help participants think about *what* executive function is and *why* this concept is important, the Air Traffic Control metaphor effectively structured an understanding of *how* children develop and hone these skills and abilities. In earlier unprimed interviews, participant discussion about how executive function develops was thin, unspecific and largely unstructured.[xx] Below is a more detailed discussion of the ways in which the metaphor supported this specific understanding.

1. **Skill begets skill:** Using the Air Traffic Control metaphor, participants were able to discuss a process through which children develop executive function skills. They described this process as starting "early and small," with things like facial recognition which then build gradually into more complex skills (e.g., sequencing, prioritizing). Participants described the process as being one in which the child first learns to be able to do a part of the task and then uses this skill to build a more complex ability. Practice doing things in which these skills could be applied was identified as the key component in moving through this step-by-step process.

   > It's like, you have to learn about order. And that's how the Air Traffic controls what plane comes in first, what plane comes in second, what leaves, what goes out, the way of organization. Like an example would be like, when they're a baby, when they're hungry they cry, and then the parents feed them, and as the child learns that when they're hungry they'll cry and then someone will bring them a bottle, and then as they get older, they learn to speak, and say I'm hungry, and they get what they need that way, and as time goes on, and they learn how to get dressed, they learn about ordering, and once they get more advanced, like when they go to write with a pen, they try and write with the cap on it, they realize they have to problem solve and remove the cap before they can write. It's just the whole, things going in and out, their thought processes of what steps need to be taken to get the airplanes to land, and the airplanes to take off, so to speak.
   >
   > Participant in Persistence Trial

   > At first it is an instinct. At first they cry because they're uncomfortable, but after a while, they realize that when they cry someone is gonna come for them. They're learning that there's some process. At first it *is* an instinct, but learning takes over after a while, and they realize that if they do something, there is gonna be a reaction to that by other people. So they're processing things, and figuring out what works and what doesn't. In the Air Traffic Control comparison, they're learning how to make the planes take off, and make them land the way they want them to … so that they can accomplish the goals that they want.
   >
   > Participant in Persistence Trial

2. **Serve and return:** Participants saw a strong role for interpersonal relationships, interaction and "back and forth" in how a child acquires Air Traffic Control skills. Analysis revealed that participants were able to export this idea of interpersonal

acquisition of skills to thinking, talking and understanding how a child would develop executive function skills. In this way, participants discussed the importance of a child's interaction with responsive caregivers who can model things and help them through challenges from which they can develop their own Air Traffic Control abilities. Many of these discussions had a striking resemblance to the concept of "scaffolding" discussed in the science of executive function.[xxi]

> I think it means you have to talk to the baby. You might think oh "baby's too young, da-da-da-da-da," but they're not. And I see a lot of people that are, just yakking away on their cell phone as they're pushing a baby in the stroller. I think even little moments like that are moments when you can be talking to your kid pointing out things, input. Input is where they start and then they pick and choose what am I gonna use at the moment? Oh, color, dog, tree, whatever, and so that is also the beginning of control. What they react to.
>
> Participant in Persistence Trial

> **Moderator**: How do you think children get executive function?
>
> **Participant**: In my opinion, it starts out very basic with working with your child from a baby on up. From recognition to when a child becomes more cognizant of its whereabouts and so forth in back and forth and, you know, working with that child in identifying body parts, reading to them, conversing with them, and having that interaction back and forth with that child. So that's pretty early and it progresses and builds on up …
>
> Participant in Persistence Trial

Inoculation. Apart from the model's effectiveness in being applied to think about key aspects of executive function, the most significant challenge for Air Traffic Control was to *inoculate* against dominant ideas associated with development, skills and abilities and default understandings of executive function. By "inoculation," we mean that an effective simplifying model deactivates the default ways of understanding the issue by supplanting these understandings with new perspectives. Wielded by participants, the simplifying model makes the dominant model less robust in the conversation.[xxii]

The dominant models that Air Traffic Control countered, or inoculated against, included:

1. Against the Mentalist cultural model

In cultural models interviews, informants had a strong tendency to apply what FrameWorks calls a *mentalist model*. When Americans think with this model, they tend to view outcomes and social problems as a result of *individual* concerns that reflect *internal* motivation and *personal* discipline. As such, the use of mentalist models by the public on issues related to early childhood development has a narrowing effect — it boils down complex interactions between individuals, contextual determinants and systems to either the presence or absence of individual motivation and internal fortitude.[xxiii]

Despite the perceptual clout of this assumption, when participants were exposed to the Air Traffic Control simplifying model, their conversations indicated that they saw that the success of a child was dependent on *the brain's* mechanism of Air Traffic Control — rather than the child's internal sense of discipline, drive and/or motivation. We conclude that the idea enabled a realization that children's skills and abilities are not determined by individual qualities (e.g., discipline, drive) but are integral to the architecture of the brain that shapes key aspects and areas of functioning.

In one example, from a Persistence Trial in Boston, a participant began talking about how the problem with kids is that "they lack discipline and respect." Another participant responded by employing Air Traffic Control as a set of abilities that are central to a child's general functioning, which turned the direction of the conversation from individualist (or mentalist) factors toward more biological, skill-based and developmental ones.

In another example, a participant began to discuss "control" and initially interpreted this concept through the lens of the mentalist model — describing control as the ability to follow rote rules and instructions. However, the participant shifted in the course of this discussion to talking about what control would mean in terms of Air Traffic Control. When thinking through the metaphor, the participant redirected the conversation back to the idea of "control" as the *ability* to direct attention, control and inhibit distraction, and focus on steps, planning and goals.

2. Against the Family Bubble cultural model

A second cultural model that emerged from earlier interviews is the *family bubble*. Through this lens, Americans view the family and the household as the sole site of all expressed behavior, learning and child development. This perception makes much of the science of executive function and its policy implications decidedly "hard to think."[xxiv]

The Air Traffic Control model was effective in inoculating against this dominant assumption. In several cases, participants began taking conversations into this translationally-unproductive direction. In these cases, other participants were able to use the Air Traffic Control simplifying model to redirect conversations to the subjects of skills and abilities; the importance of training and practice in developing these skills; and the importance of executive function as a result and determinant of child development. In short, the focus on a concrete set of skills and the perceived importance of this set of abilities kept conversations from turning into a series of stories about good and bad parents and their effect on good or bad kids — tropes that FrameWorks research on child development, child mental health and education often revisit.

3. Against the Default Development cultural model

The *default development model* structures an understanding of child development in which this process proceeds in a natural progression. Operating from within this perspective, people do not see things like the quality of social interaction or specific environmental characteristics as critical for how children develop skills and abilities. Instead, children's development is seen to merely "unfold naturally"; the environments to which children are exposed (and the experiences they have there) are seen as inconsequential in their "natural" progression towards becoming either a "successful" or "unsuccessful" individual.[xxv]

In discussing the Air Traffic Control model, participants appeared to realize and appreciate why children should get executive function skills early. Participants seemed to be able to see that children need to acquire and develop these skills very early in their lives, as completing subsequent activities and developing other skills was contingent upon the strength of these foundational skills. By structuring an understanding in which executive function skills were foundational in development and life more generally and that these skills require active training, the Air Traffic Control metaphor effectively inoculated against assumptions that what happens early is of no great consequence.

4. Against the Basic Competencies are Moral Characteristics cultural model

The difference between the conversations following exposure to the Air Traffic Control metaphor and those occurring in response to the open-ended questions of early interviews was marked. In these earlier interviews, informants overwhelmingly articulated that "responsibility" was the basis for developing appropriate competency and functioning — encompassing respect for others, respect for oneself, knowing "right from wrong," doing what's right, and having a sense of obligation. In short, informants in this earlier research saw *responsibility* as the most important and most basic "skill" required for an individual to function.[xxvi]

In persistence trials, these discussions were simply not present. After exposure to the simplifying model, participants' discussions of skills and abilities that children need focused squarely on topics like focus, attention control and management, filtering distractions, and shifting gears.

5. Against the Passive Child cultural model

Previous FrameWorks research has shown that there is a dominant American cultural model in which children are assumed to be passive recipients of developmental content — that they are simply "sponges" that absorb what is around them, or containers that are filled with the developmental content that parents pour in. We call this the *passive child model*. This leads to interpretations in which children's development is a passive, rather than an active, process, in which development happens, in the words of our participants, as if "by osmosis."

In conversations about how someone develops Air Traffic Control skills and abilities, participants related a clear sense that executive function skills "don't just happen by themselves," as one participant put it. The focus on the necessity of active cultivation of skills rather than their passive absorption is another indication that the Air Traffic Control simplifying model was effectively inoculating against obstructive dominant models.

6. Against the Individualist cultural model

In cultural models interviews, informant discussions revealed an assumption of *individualism*. This model shaped frequent discussions of how different one child is from the next, making informants resist statements about the factors that affect *all* children, or the skills and abilities that *all* children need. Put another way, informants appeared to reason that since kids are so different, generalizations are inappropriate.[xxvii]

In several places in the Persistence Trials, participants used the concept of Air Traffic Control to counter this focus on individualism. In one such case, a participant began to voice the familiar trope of individual differences and the inability to say anything general about child development.

This pattern of talk did not take hold, and another participant employed the metaphor of Air Traffic Control to steer the conversation away from this postmodern inclination — explaining that there actually are things that we can say about all children and how they need to be able to process information. The conclusion appeared to be that all children (as well as adults) need an Air Traffic Control mechanism in order to function.

Self-Correction. Persistence Trials also showed that Air Traffic Control is able to self-correct. Self-correction refers to a simplifying model's ability to snap back to its initial form following a deterioration of the concept in public discussion. An important measure of a model's strength, self-correction occurs when one structural feature of the metaphor that had been forgotten, drops out of conversation or devolves into some alternative interpretation, re-asserts itself in discourse. When communicated in the public sphere, simplifying models are likely to break down. Therefore, it is important that a concept have enough internal coherence to recover from such devolutions — to encourage people to arrive at key entailments that have been communicated in partial or inaccurate form.

A prime example of the self-corrective ability of the Air Traffic Control model occurred when, in a Persistence Trial, the metaphor was interpreted as a plan for how to, literally, train children to become Air Traffic Controllers. This understanding was relayed to the next set of participants, who were able to reinstate the metaphorical nature of the discussion and see that the Air Traffic Control idea was a general metaphor for a set of skills and abilities that are important for children to develop, rather than a specific set of skills that children need in order to become air traffic controllers. This demonstrates how a simplifying model can reassert its original form, and how this model returned to its figurative function as a way of understanding a set of skills and abilities that are important in the process of child development.

Communicability. The central ideas of the Air Traffic Control model were sticky across the pairs of participants in Persistence Trials — they were "communicable." That is, people were successful at preserving and relating the sense of the specific skills that comprise and are required in Air Traffic Control; the understanding of why these skills are important for children and their development; and the perception of how these skills are developed.

Refinements. An additional function of the Persistence Trials is to gather data that allow empirically-based final refinements of a simplifying model in order to ensure that the final form of the simplifying model is maximally effective. The issues described below also suggest strategies (and tactics to be avoided) in the use and application of the Air Traffic Control model. Below is a description of the ways in which data from the Trials suggested additional refinements to the Air Traffic Control simplifying model and the ways that the model was refined to account for our findings.

1. **A potentially derailing discourse combination:** One potential problem observed in Persistence Trials was the way that a few participants discussed "distractions." In many cases, discussions of Air Traffic Control led to talking about the importance of being able to manage distractions — a positive entailment, as inhibitory control is a key dimension of the science of executive function. However, in a few cases, the topic of "distractions" occurred in the context of discussions about computers and technology, which cued a sticky, derailing discourse about the evil of computers in the modern world. Talking about "distraction" together with "computers" cued (for some informants) a pattern of

thinking about the evils of technology as the reason "why kids today can't focus on anything."

Though infrequent, this pattern was highly derailing. This suggests the need for users of this model to avoid discussions of digital technology in conversations about executive function, and to specify other types of distractions in accompanying materials to fill the slots in people's thinking.

2. **The Aging-Up problem:** As with other research that FrameWorks has conducted on children's issues,[xxviii] there was a tendency in Persistence Trials for participants to "age-up" the subjects of their discussions. That is, they focused their discussions of Air Traffic Control and development on older children, usually adolescents. While executive function is certainly important for adults and adolescents, one of the goals of the research described here was to design a simplifying model that encouraged the realization of the importance of executive function skills *for young children.* Final refinements of the model were made to include more specific references to the age of children about which the simplifying model communicates.

3. **The "Controller" problem:** Persistence Trials showed that when discussions of Air Traffic Control became discussions of Air Traffic Control*lers,* space was created for the application and articulation of two dominant cultural patterns that Americans use to reason about child development. When discussions moved to focus on *who* the Air Traffic Control*ler* is, space was created for participants to employ their existing dominant cultural models to fill in this information. And because of the strength of the family bubble cultural model,[xxix] "parents" became the easiest answer to this question. Once this occurred, the realm of parental responsibility, not the brain, became the sphere of Air Traffic Control and executive function.

In addition, when conversations about Air Traffic Control *skills* and *mechanisms* became conversations about Air Traffic Control*lers,* conversations narrowed in on ideas of personal responsibility and the importance of drive and motivation. For kids to become "good" Air Traffic Controllers (went the thinking), they need to be driven and motivated. This mentalist cultural model[xxx] then structured participants' answers about how kids get these skills, leading informants to explain that developing executive function skills was all about whether or not the child "really *wanted* to become a good Air Traffic Controller." Once given a chance to call upon this well-rehearsed pattern of thinking, participants had difficulty articulating that the responsibility for the development of executive function skills and the outcomes they support does not lie *within* the child, but in environments that structure and afford activities that recruit executive function skills.

To address this tendency, the final iteration of the simplifying model more firmly framed Air Traffic Control as a mechanism in the brain.

CONCLUSION: APPLYING THE SIMPLIFYING MODEL

This research has shown that the Air Traffic Control simplifying model stands to make a significant contribution to framing child development and more specifically to the science of executive function. The metaphor proved to be highly understandable, applicable, communicable, self-correcting, able to inoculate against damaging dominant perspectives and impactful in the way that our sample of Americans perceive the foundational skills and abilities that result from and facilitate child development. For these reasons, FrameWorks offers this new strategic frame element to aid in translating the science of and reframing the public conversation around child development.

We conclude with two notes of caution in the application of simplifying models in general and Air Traffic Control more specifically. First, the simplifying model suggested here was tested both for its underlying concept and with respect to the highly targeted linguistic execution of this concept. Therefore, the emerging model represents both an effective metaphor and an effective linguistic packaging of the metaphor. A certain latitude and flexibility in the use and application of Air Traffic Control is to be expected, even encouraged. Yet the specific concept and language that appear in the report have empirically demonstrated effectiveness. We do not claim to know the results or effectiveness of using alternative but related concepts or dramatically different linguistic packagings. In short, scientists, practitioners and advocates should include the following basic elements in using the simplifying model:

The Brain's Air Traffic Control Mechanism

> A. Air Traffic Control is **a set of skills and abilities**.

> B. Being able to Control Air Traffic requires skills like: **coordination; prioritization; management of incoming information; holding and working with information in mind; attention and distraction control; and being able to shift gears**.

> C. Air Traffic Control is rooted **in the brain**.

> D. Air Traffic Control develops through **practice**, **training** and by having experiences in which children have the opportunity to **apply these skills**.

> E. Air Traffic Control is necessary for an airport to **function**; where there are multiple streams of incoming information and finite mental airspace.

> F. The Air Traffic Control mechanism **develops early**.

In conclusion, the research presented in this report has shown how the Air Traffic Control simplifying model can be applied to the domain of executive function and move people from perspectives like these:

> Interviewer: What skills and abilities do you think children need to function?

> Informant: I think loving yourself is essential, absolutely 100 percent more important than anything else.
>
> <div align="right">Participant in Cultural Models Interview</div>

If you are around intellectuals a lot, you're going to speak intellectual. Just by osmosis, it has to [be]. It's a fact. And so, a competent kid, is going to be *around* competent people.

<div align="right">Participant in Cultural Models Interview</div>

To perspectives like this:

This idea that we've been talking about is the analogy that Air Traffic Control is similar to the function of the brain, the area of the brain that enables executive function, which enables us to focus on any particular task or to be geared up and focus on what is pertinent in front of us at any given time. So it's basically a sifting device. It allows us to concentrate on the important issues at hand versus being diverted. It's a filtering process and with the Air Traffic Control concept, it would be that instructors, teachers, parents have to help kids to concentrate on their task at hand which is helping this child realize what goals and objectives and tasks they have immediately at hand and what to concentrate on so we can all become more productive members of society.

<div align="right">Participant in Persistence Trial</div>

About FrameWorks Institute

The FrameWorks Institute is an independent nonprofit organization founded in 1999 to advance science-based communications research and practice. The Institute conducts original, multi-method research to identify the communications strategies that will advance public understanding of social problems and improve public support for remedial policies. The Institute's work also includes teaching the nonprofit sector how to apply these science-based communications strategies in their work for social change. The Institute publishes its research and recommendations, as well as toolkits and other products for the nonprofit sector, at www.frameworksinstitute.org.

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APPENDIX: THE METHODOLOGICAL APPROACH TO IDENTIFYING AND TESTING SIMPLIFYING MODELS

I. PHASE 1: MAPPING THE GAPS

In the first phase of this simplifying models research process, FrameWorks employed an interview method called cultural models interviewing. Using a detailed interview guide, interviewers asked questions aimed at getting at how average Americans understand and approach the issues of fundamental skills and abilities and executive function.

More generally, cultural models interviews reveal the cognitive "terrain" on a given issue by focusing on the implicit patterns of assumptions — or cultural models — which individuals employ to process incoming information on an issue. These patterns are the "mental bins" into which people try to fit incoming information and represent both potentially productive and damaging ways of making sense of information. To uncover the gaps in understanding on the target issues, we held the findings from cultural models interviews up to data gathered from experts on executive function. FrameWorks calls this process "mapping the gaps."

II. PHASE 2: DESIGNING SIMPLIFYING MODELS

After identifying the gaps in understanding, the second phase of the simplifying models research process aimed to generate a set of candidate simplifying models that were then empirically explored and tested in the third research phase. The result of the design process is a list of both metaphorical categories (e.g., "Orchestrating," "Intertwining") and multiple iterations or "executions" of each category (e.g., "Air Traffic Control," "Rope"). FrameWorks' linguist analyzes all of the transcripts from the "mapping the gaps" phase of the research process and generates a list of metaphor categories that represent existing conceptual understandings that can be recruited, as well as overlap between the experts' and general public's use of metaphorical language and concepts. The linguist generates metaphor categories that capture the *process* element of the expert understanding in metaphors that, given the data gathered from members of the general public, have the potential to be easily visualized and incorporated into thinking about the issue under consideration (i.e., fundamental skills and abilities and executive function).

FrameWorks researchers who are specialized in cultural models and cognitive theory conduct a cognitive analysis of the model categories, which examines the *expected* public response to the metaphors based on cultural models theory and existing FrameWorks research on cultural models that Americans employ in understanding child development in general and executive function more specifically. Researchers then use this analysis to review the metaphor categories, adding new possibilities and suggesting ones to be cut. At this stage, researchers also compare the candidate metaphors to the data from the initial cultural models interviews. Metaphor categories that contain elements or aspects of models found to be damaging or distracting in the public's thinking about the topic are suggested as categories to be eliminated from the candidate list. On the other hand, simplifying model categories containing elements of more productive cultural models are highlighted as particularly promising.

During the process of designing candidate simplifying models, FrameWorks also assesses the models' abilities to be incorporated into practice by journalists and advocates/practitioners. In some cases, this practical assessment has suggested that some candidate models are too

provocative or insipid to pass into the public discourse. These models are removed from the working list. The refined list is then returned to the linguist, who begins to compose iterations or executions of the categories on the list. The list of categories and iterations is sent back to FrameWorks' researchers for additional revisions.

PHASE 3: TESTING SIMPLIFYING MODELS — THREE TESTS OF MODEL EFFECTIVENESS

TEST I: ON-THE-STREET INTERVIEWS

As the initial opportunity to test candidate simplifying models, on-the-street interviews present an ideal opportunity to gather empirical data on the effectiveness of candidate simplifying models — which specific elements of the models are functioning well, and which aspects are less successful in clarifying concepts and shifting perspectives.

The metaphors are written up as "iterations," paragraph-long presentations that cue the listener/reader to two domains of meaning, one of which is typically referred to as the "source," and the other of which is known as the "target." In the metaphorical statement "encyclopedias are goldmines of information," the source domain of meaning is "goldmine" and the target is "encyclopedias." In FrameWorks' terms, "encyclopedias" is the target because it is the object or process that the application of knowledge about goldmines is meant to illuminate.

In March 2009, FrameWorks tested a total of six candidate simplifying models in Boston, Mass., and Baltimore, Md. Each candidate model was presented orally, in separate interviews, to approximately three informants in both locations for a total of six interviews per model, comprising a total data set of 36 10-minute interviews. All informants signed written consent and release forms and interviews were video and audio recorded by a professional videographer.

The six models tested represented executions of four candidate simplifying model categories. Two iterations of the "Orchestration" category were explored because analysis suggested sufficient difference between these iterations to warrant exploration of both ideas. Data from the interviews were used to winnow and refine categories as well as to refine the individual executions of metaphors within categories.

Subjects

A total of 36 informants were recruited on site in the two locations. A FrameWorks researcher approached individuals on the street or walking through a mall and asked if they would be willing to participate in a short interview as a part a research project on "issues in the news." The recruiting researcher paid particular attention to capturing variation in gender, ethnicity and age.

Data on each informant's age and party affiliation, as self-identified, were collected after the interview. Efforts were made to recruit a broad range of informants. However, the sample is not meant to be nationally representative. Although we are not concerned with the particular nuances in how individuals of different groups respond to and work with the simplifying models tested in these interviews, we recognize the importance of between-group variation, and take up this interest in quantitative testing of simplifying models — where the virtues of quantitative sampling techniques can effectively and appropriately address issues of representativeness and across group variation.

The Interview

FrameWorks had the following goals in designing and conducting on-the-street interviews: (1) identify particularly promising simplifying model categories, (2) refine those categories with more mixed results and (3) eliminate highly problematic categories, in which the underlying *concept* created problems that could not be overcome by refining existing or designing new executions. FrameWorks' approach to this winnowing process is highly conservative to assure that only the most unproductive categories — those that are beyond repair — are eliminated. However, winnowing is a necessary feature of a process that intentionally produces a large set of possible iterations, but that culminates in the one most effective simplifying model.

More specifically, interviews were designed to gather data that could be analyzed to answer the following questions:

A. Did the informants *understand* the model and its underlying metaphor?

B. Did they *apply* the model to talk about skills and abilities and executive function?

C. Did the model *shift* discussions away from the dominant thought patterns that characterized the initial responses?

D. Did exposure to the model *lead to more articulate answers and robust, fully developed conversations* of issues that informants had problems discussing prior to being exposed to the model?

The interview began with a short series of open-ended questions that dealt with fundamental skills and abilities as well as discussion of a scientific explanation of executive function. The interviewer then discussed one of the candidate simplifying models using a memorized but conversational script. Following this exposure to the simplifying model, the researcher asked informants a second series of open-ended questions designed to gauge the effect of the simplifying model in shifting perspectives on skills and abilities and executive function and in facilitating more robust conversations around these issues. Some of these questions were reformulations of the initial questions using different language so as not to appear repetitive.

TEST II: QUANTITATIVE EXPERIMENTAL RESEARCH

After analyzing on-the-street interview data, the categories that emerged as successful in on-the-street interviews (see below) were built out to include other iterations. FrameWorks subjected this refined and expanded set of simplifying models to an online quantitative experiment. The overarching goal of this experiment was to gather representative and statistically powerful data on the models' effectiveness. These data then provided an empirical basis to select one or two models that were most successful relative to a set of theoretically driven outcome measures. In the end, experimental data were used to select and refine one model that was then taken into the final stage of the empirical testing process.

Four categories and two iterations of each category were developed and brought into testing:

     1. Orchestrating:.

- *The Caddy Effect: A child's ability to focus and pay attention is like the caddy for a professional golfer.*
- *The Conductor Effect: A child's ability to focus and pay attention is like an orchestra conductor.*

2. Intertwining:
- *The Weaving Effect: Executive function skills are like the strands of a rope.*

3. Programming:
- *The Computer Effect: Executive function is like an operating system that helps run the brain.*
- *The Stereo Effect: The brain is the stereo that needs to be adjusted, but at first it doesn't come with all the controls it needs to do its job.*

4. Gating:
- *The Doorkeeper Effect: A child's ability to focus and pay attention is like the door to a building, which is controlled by a doorkeeper.*

In April 2010, FrameWorks conducted the experiment, which measured the performance of eight candidate simplifying models and four metaphor categories in relation to a set of outcome measures. The survey was conducted online with 2,000 participants who were drawn from a national online panel. A nationally representative sample was first created. Individual members of an online panel were then selected to "match" members of the sample — constructing a nationally representative experimental sample.

Experimental Design

Following exposure to one of nine "treatments" — paragraph-long iterations of candidate metaphors — participants answered a series of questions designed to measure a set of theoretically-based outcomes. Effects were compared both across and within categories — meaning that specific iterations were tested against other iterations both within and across categories.

Treatments

In designing the experiment instrument, multiple iterations were generated by a linguist as alternative representations of the larger metaphor categories. For example, the Orchestrating category included iterations for the Air Traffic Control and Switchboard Effects, while Intertwining contained Rope and Fabric as specific instantiations.

In total, eight specific simplifying model iterations were developed. Each treatment consisted of a paragraph that described the metaphor, as in the following example:

Air Traffic Control: Children's ability to focus and pay attention is like Air Traffic Control at a busy airport. Some planes have to land and others have to take off at the same time, but there's only so much room on the ground and in the air. In the brain, the mechanism that acts as Air Traffic Control is called executive function. It regulates the flow of information and the focus on tasks, creates mental priorities and avoids collisions, and keeps the system flexible and on time. In children, this mechanism needs to be actively geared up as early as possible.

Among iterations, only the name of the model (e.g., Air Traffic Control), entailments and structural features specific to that metaphor, and appropriate lexical items or phrases differed. This balance of *variation* between models and *standardization* in construction and language is designed to ensure that any differences in effect were due to differences between the models themselves, and not to some unintended confounding variable.

Outcome Measures

After receiving the treatment paragraph, participants were asked a series of multiple choice questions to test each model's performance in relation to three outcome measures; understanding, application and aptness.

TEST III: PERSISTENCE TRIALS

After using quantitative data to select the most effective model, FrameWorks conducts Persistence Trials to answer two general research questions: (1) *can* and *do* participants transmit the model to other participants with a reasonable degree of fidelity? and (2) *how* do participants transmit the model? In other words, the method examines how well the simplifying models hold up when being "passed" between individuals, and how participants use and incorporate the models in explanation to other participants.

The Persistence Trial

A Persistence Trial begins when researcher presents one of the candidate simplifying models and asks the two participants a series of open-ended questions designed to gauge their understanding of the simplifying model and their ability to apply the model in discussing the target domains (fundamental skills and abilities and executive function more specifically). For example, the researcher asked how the participants understood the simplifying model; what they imagined the source domain (e.g., Air Traffic Control) referred to; and how the idea presented related to fundamental skills and abilities. Questions and analysis were also designed to locate any terms or ideas in the execution of the model that participants had difficulty with or explicitly recognized as problematic.

After 15 to 20 minutes of discussion between the two initial (hereafter referred to as "Generation 1") participants and the interviewer, Generation 1 was informed that they would be "teaching" the simplifying model to another group of two participants (Generation 2). Generation 1 was given five minutes to design a way of presenting the simplifying model, after which they had five minutes to present the simplifying model to Generation 2. Generation 2 then had five to ten minutes to ask Generation 1 questions about the presentation. During this time the interviewer generally allowed dialogue to unfold naturally between the two groups but periodically probed for additional information on ideas that emerged.

Generation 1 then left the room and the interviewer asked Generation 2 an additional set of questions designed to elicit their understanding of the simplifying model and ability to apply the concept. This questioning lasted for approximately 10 minutes, at which point Generation 2 was informed that they would be "teaching" the idea to two new participants (Generation 3). Generation 2 had five minutes to plan their presentation, after which Generation 3 entered the room and the two groups went through the same steps and questions as described above.

A Persistence Trial ends when Generation 1 returns to the room, where they are allowed to debrief with Generation 3 on the direction the metaphor has taken. The interviewer then reads the original paragraph-long iteration and asks questions about its transmissibility.

For the executive function research discussed here, FrameWorks tested one candidate simplifying model (Air Traffic Control) in Phoenix, Ariz., and Boston, Mass., in April 2010. The candidate model was tested in three Persistence Trials. All informants signed written consent and release forms prior to participating in the sessions, and interviews were video and audio recorded by professional videographers.

Subjects

A total of 18 informants participated in Persistence Trials. These individuals were recruited through a professional marketing firm, using a screening process developed by and employed in past FrameWorks research. Informants were selected to represent variation along the domains of ethnicity, gender, age, educational background and political ideology (as self-reported during the screening process).

Analysis

In analyzing data from Persistence Trials, FrameWorks sought to answer the following specific questions in relation to each simplifying model:

A. Were participants able to *apply* the simplifying model; and more specifically *what* were the ways in which they applied the model?

B. Was the simplifying model *communicable?* Were Generation 1, 2 and 3's presentations of the simplifying model faithful to the initial model presented by the interviewer? How did the groups' presentation of the model differ from that presented by the interviewer (i.e., did they use different language, use different ideas related to the metaphor, emphasize different entailments etc.)?

C. Did the simplifying model *inoculate* against the dominant default cultural models? That is, did the model prevent discussions from falling back to any dominant but unproductive cultural models that attach to the issue? Furthermore, if one of these cultural models did become active, could the simplifying model prevent the discussion from veering narrowly in these perceptual directions?

D. Did the simplifying model *self-correct*? That is, if one Generation's presentation was not faithful to the original simplifying model or left out a key component, did the ensuing Generation's interpretation and/or presentation self-correct?

E. What specific *language* did the groups use in discussing the model? Was there language that participants used that was not included in the original execution of the simplifying model?

As described in the main body of this document, Air Traffic Control produced a number of beneficial effects on participants' talking about fundamental skills and abilities and the science of executive function.

NOTES

[i] For more about SFA, see http://www.frameworksinstitute.org/sfa.html.

[ii] Quinn, N., & Holland, D. (1987) Culture and cognition. In Holland D., & Quinn, N. (Eds.). *Cultural models in language and thought*. Cambridge, MA: Cambridge University Press, pp. 3-40.

[iii] See: Lévi-Strauss, C. (1963). *Totemism*. Translated by Rodney Needham. Boston, MA: Beacon Press. And Lévi-Strauss, C. (1966). *The savage mind*. Chicago, IL: University of Chicago Press.

[iv] It is important to note here that "dominant cultural model" is a term used to denote the relative pervasiveness, power and "stickiness" of a set of shared assumptions. In other words, the degree to which the model is top of mind, crowds out other ways of thinking, and attaches solidly and "virally" to the discussion around a topic. However the term *does not denote or carry with it any positive or negative valence.* Dominant cultural models can be productive in structuring policy thinking just as they can be unproductive in creating space for these perspectives.

[v] Kendall-Taylor, N., McCollum, C., & and Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[vi] Quinn, N. (2005). *Finding culture in talk: A collection of methods, p. 3*. New York, NY: Palgrave Macmillan.

[vii] Kendall-Taylor, N. (2010). *An empirical simplifying models research process: Theory and method.* : Washington, DC: FrameWorks Institute.

[viii] See: Iyengar, S. (1991). *Is anyone responsible? How television frames political issues*. Chicago, IL: University of Chicago Press. And Iyengar, S., & Kinder, D. (1987). *News that matters: Television and American opinion*. Chicago, IL: University of Chicago Press.

[ix] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[x] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xi] Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: The University of Chicago Press.

[xii] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xiii] Holland, D., & Quinn, N. (1987). *Cultural models in language and thought*. New York, NY: Cambridge University Press.

[xiv] See Lakoff, G. & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: The University of Chicago Press. And Shore, B. (1996). *Culture in mind: Cognition, culture, and the problem of meaning*. New York, NY: Oxford University Press.

[xv] Those familiar with FrameWorks research may recall earlier studies that included what we then referred to as "TalkBack Testing." "Persistence Trial" research is an expanded and updated method that now replaces TalkBack Testing.

[xvi] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xvii] Jones, L., & Estes, Z. (2006). Roosters, robins, and alarm clocks: Aptness and conventionality in metaphor comprehension. *Journal of Memory and Language*, 55, 18-32.

[xviii] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xix] Ibid

[xx] Ibid

[xxi] Ibid

[xxii] Relevant dominant models related to development and executive function are outlined in FrameWorks' cultural models report on these subjects See: Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute. And Brown, A., Aubrun, A., & Grady, J. (2006). *A new understanding of interaction findings from interviews and talkback testing.* Washington, DC: FrameWorks Institute.

[xxiii] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xxiv] Ibid

[xxv] Kendall-Taylor, N. (2010). *Experiences get carried forward: How Albertans think about early child development.* Washington, DC: FrameWorks Institute.

[xxvi] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.

[xxvii] Ibid

[xxviii] Kendall-Taylor, N. (2009). *Conflicting models of mind in mind: Mapping the gaps between the expert and the public understandings of child mental health as part of Strategic Frame Analysis™.* Washington, DC: FrameWorks Institute.

[xxix] See: Kendall-Taylor, N. (2009). *Conflicting models of mind in mind: Mapping the gaps between the expert and the public understandings of child mental health as part of Strategic Frame Analysis™.* Washington, DC: FrameWorks Institute. And Kendall-Taylor, N., & McCollum, C. (2009). *Determinism leavened by will power: The challenge of closing the gaps between the public and expert explanations of gene-environment interaction.* Washington, DC: FrameWorks Institute.

[xxx] Kendall-Taylor, N., McCollum, C., & Manuel, T. (2009). *Caught between osmosis and environments: Mapping the gap between the expert and the public understandings of the role of executive function.* Washington, DC: FrameWorks Institute.