# Five Levels of Cognitive Fit: Going from Good to Great in Human-Centric Design

**Abstract**

A major trend in design is to reach beyond usability concerns and focus on creating artifacts that generate a particular frame of mind. Positions for designing "think-and-feel" have been proposed (emotion, pleasure, fun) but no general purpose approach exists. This paper presents a general purpose approach (cognitive design) that models interaction as the conversion of mental energy. Although somewhat metaphorical, the idea is to characterize human-artifact interactions as a transformation of the mental work required to access functionality into the mental energy that is released or generated by the resulting frame of mind. The relationship between mental energy that goes into an interaction (effort, memory, vigilance) to the mental energy that comes out (meaning, visceral reaction, incidental processing) defines specific levels of cognitive fit between users and artifacts including, agitate, tolerate, resonate, accelerate and integrate. These frames on mind are discussed and the example of designing for savoring is presented.

**Conference theme:** Methodological Issues
**Keywords:** Cognitive Fit, Mental Energy, Cognitive Design

## Introduction

Traditionally, design specialists have been concerned with functionality and usability. The goal is to create artifacts, or anything that is intentionally designed, that are functional and easy to use. Recently, innovators in the field have started to look beyond usability in an effort to design artifacts that establish mentality or specific frames of mind in users. Examples of designing for mentality include emotional design (Norman 2004), designing pleasurable products (Jordan 2000); and the design of enjoyable products (Blythe 2004).

This paper focuses on the common denominator in these positions, namely the intent to enhance or even create a set of mental states (frame of mind) in users. The analysis is not constrained to a particular type of mental state but instead looks across the full-range of psychological experience including thought, affect, motivation and volition.

The use of the word “cognition”, in cognitive design, is not meant to imply a domination of rationality over the other aspects of how minds work. Indeed, as research in cognitive science has revealed (Zaltman 2003), the traditional notion of cognition is necessarily bound up in emotions, hopes, goals, cravings and other powerful visceral states. Cognitive design is about designing for how minds actually work and therefore must reflect the emotional, pattern-driven, automatic, metaphor-based and biased nature of mind.

In cognitive design the goal is to enhance or create a specific set of thoughts and feelings in users. Designing for a specific frame of mind means that the mental states of the user becomes part of the specification of the design problem. This is nothing new, especially in the fields of art, fashion, entertainment and luxury products. In these domains the way people think and feel when experiencing the artifact is of the utmost importance. What is new is the realization that such an emphasis is now relevant, competitively significant and even necessary for success in many if not all domains of product, service, architectural, industrial and organizational design. For example, in markets where competitors offer the same functionality and usability they have a choice to compete on price or to charge a premium based on the ability to create a certain think-and-feel in their product (Postrel, 2003). In other domains, where products and services are intended to change behaviors, failing to design for how minds work can create serious consequences in terms of safety, health and security. Think about the difficulties many have in saving for retirement or maintaining a healthy weight despite the diversity of programs and products that have been designed to help them.

This paper presents a systematic approach to cognitive design based on the basic idea that the interaction between people and artifacts can be understood as a conversion of mental energy. *We put mental energy into artifacts to learn, use and maintain them and we get mental energy out in terms of how they make us think and feel*. The relationship between the mental work we do (energy-in) and the mental benefits we get (energy-out) determines the frame of mind that is produced by the interaction. Depending on this energy-in / energy-out relationship, a range of frames of mind can be produced including agitation, toleration, resonance, acceleration and even a deep symbiotic integration. The key is to understand the cognitive science behind the factors that create mental workload (energy-in) and produce mental benefits (energy-out) and tune those through a design activity to achieve a the desired frame of mind. We present six factors (mental effort, memory load, vigilance, meaning, visceral response, incidental processing), all established in the literature, and born out in our practice, that are well suited for tuning the mental energy in/out relationship (cognitive ergonomics) for a wide range of artifacts.

Cognitive design is in its infancy. This paper proposes an initial theoretical framework based on the idea of mental energy conversion. Although applications have been successful, additional studies are needed. We have developed two subjective rating scale instruments to collect data on the predictive value of the five-levels and six-factors that make up our current approach.

**Interaction as the Conversion of Mental Energy**

Using an artifact takes work. It requires physical action and mental effort to use a product, consume a service, be entertained or experience art. We do this work to access the benefits of the functionality in the artifact. We want the outcome or value it can produce. Good designs, enduring designs, deliver an outcome that is judged to be worth the cost and effort by those that it was designed for. Although this is may be obvious, it is especially important when designing for how minds work. What counts as mental work and psychological benefit is not immediate obvious and must be managed carefully if we are to achieve a particular frame of mind. One way to approach this is to view interaction with an artifact as a conversion of mental energy. Although somewhat metaphorical, the idea is to characterize human-artifact interactions as a transformation of the mental work required to access functionality into the mental energy that is released or otherwise generated by the resulting frame of mind. Under this framing, cognitive design is a matter of influencing the factors that drive mental workload and the generation of energy associated with the mental benefits the artifact brings.

For example, we can sit in the immersive environment of a movie theater and do no conscious mental work but experience the release of tremendous mental energy through laughter (comedy), fear (horror move) and even anger (documentary with a strong message). If we like a movie we report that the energy-out far exceeds the mental work needed to watch it. On the other hand, if we find the movie to be pertinacious or boring we signal that at least for us, it requires more mental work than it is worth. A good movie (or other artifact the designed for how the minds works) will create more energy than it consciously requires to view (use).

If the conversion of mental energy as a focus for design is to be more than a metaphor we must explore the underlying cognitive science. More specifically, we need a way to characterize the factors that drive mental workload (energy-in) as well as those that drive the generation of mental benefits (energy-out).

**Mental Workload or Energy-In**

Considerable empirical work has been done to measure the workload associated with tasks and interactions with various types of artifacts (Sherehiy, Karwoski, 2006). Techniques range from subjective rating assessments to analytical methods and physiological measurement of attention, effort and stress. Our research has focused on the mental components of subjective rating assessments that have proven reliable and practical for field use. We have adapted components of the NASA task load index and the Subjective Workload Assessment Technique (Sherehiy, Karwoski, 2006) to focus on an estimate of:

- Mental demand or effort as determined by the amount of perception, decision making, problem solving, learning and other mental processes are involved.
- Temporal demand as determined by the amount of time pressure or conversely spare time that is experienced during interaction with the artifact.

Subjective estimates of mental and temporal demand provide some design guidance. To gain additional design insights we include two more factors inspired by work on cognitive load (Paas, Renkl, Sweller, 2003) and the cognitive science on the nature of self regulation (Baumeister, Vohs, 2004). These include:

- Conscious memory demand or the number and level of abstraction of items that must be managed by working memory or in prospective memory to learn or use the artifact.
- Vigilance demand as determine by the need for situational awareness, conscious self-regulation or other mental activities that invoke an executive level function.

The vigilance demand is especially important for artifacts designed to cause changes in thinking or behavior or that involve safety issues.

As a conceptual formula the four demand factors are:

Mental energy-in = (mental effort + conscious memory + vigilance) * duration

For example, if I need to make many decisions on when to use particular features, remember a long series of steps, constantly watch for particular readings or fight a natural tendency towards boredom I will need to inject increasing levels of mental energy into the interaction.

**Mental Benefit or Energy-Out**

Mental energy like physical energy cannot be created or destroyed. Mental energy-in must be converted into a different form or the mental energy-out. We can model the energy conversion process using the ABC theory that has been successfully applied in cognitive therapy (McMullin, 2000). Under this interpretation interaction with the artifact draws our attention through an activating event (A) which triggers a series of beliefs (B) that can be complex (e.g. activate a mental model) or simple (e.g. trigger an association) which in turn generate one or more emotional and behavioral consequences (C). Substantial cognitive sub-processing guides the ABCs of any interactions. For example, expectations and self concept tune attention-based resources; selective memory, appraisal and attribution determine how the activating event is categorized and therefore the beliefs, emotions and mental models that are activated; and evaluation and self-instruction inform the behavioral reactions that are produced (see figure 1).

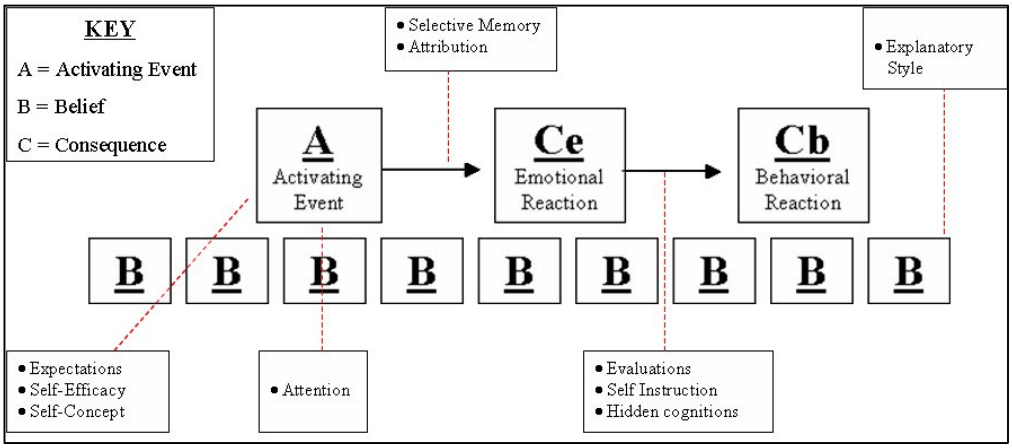


Figure 1: The ABCs of Mental Energy Conversion

This process outlines the basic dynamics of the energy conversion in very general terms. The challenge is to pinpoint those types of beliefs that are most important for producing mental energy. A review of the literature suggests a focus on four aspects of the conversion process including, attribution or forming highly personalized meanings (Krippendorff, 2006); triggering visceral factors including emotions, drive states (pain, hunger, thirst, sexual desire) and cravings (Loewnstein, 2004); and incidental mental processing triggered by metaphors, cognitive biases, heuristics or the activation of mental models (Gigerenzer, Todd, ABC Research Group, 2000).

If we include duration, a conceptual formula for the production factors is:

Mental energy-out = (meaning + visceral response + incidental processing) * duration

Interactions that are meaningful, invoke a robust visceral response (emotion, drive state, craving) and trigger incidental processing (e.g. reminiscing, heuristic response, automatic and deep or broad associations) will tend to generate high levels of mental energy.

**Energy Conversion and Cognitive Ergonomics**

We assume mental energy is like physical energy and must be conserved. The energy-in equals the energy-out. This claim is a good tool for designers but does not reflect the subjective experience of users during an interaction. For example, I may do a lot of mental work to memorize a book of baseball statistics but if baseball fascinates me I may report no mental effort at all. The learning and memory load is high but it is being masked by meaning and visceral factors with a strong positive valence.

Good design creates the perception, feeling or frame of mind that more energy is coming out of the interaction then is going in. The stronger that perception is the better cognitive ergonomics you have. *As a fundamental principle, the level to which an artifact fits how minds work is determined by the perception of how much energy is created by interacting with the artifact*. The perception of energy created or lost through interaction reflects this degree of fit and can be described by a general frame of mind produced by the interaction. Our research has shown that artifacts that require more energy than they produce agitate users whereas artifacts that are balanced or deliver as much mental energy as they require are tolerated. Further, artifacts that produce more energy resonate with users and artifacts that produce much more energy, by improving mental effectiveness actually accelerate the cognition of people that interact with them (See figure 2).

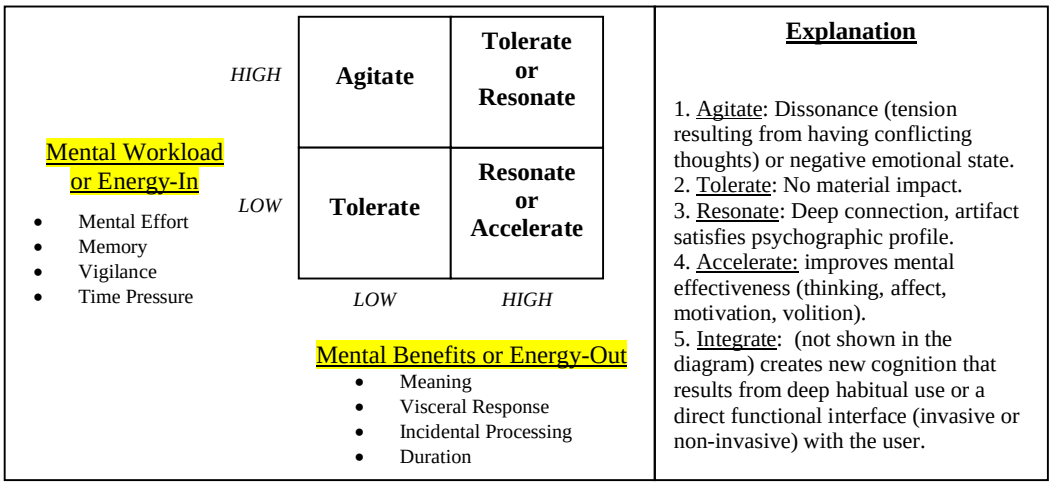


Figure 2: Energy and Fit in Cognitive Design.

A more complete explanation of the five levels of cognitive fit can be found on the Cognitive Design Blog (Clare, 2007).

**Agitation**

To achieve a level of fit the designer changes the properties, features, or form of the artifact to directly impact one or more of the six factors. To illustrate, we will look at agitation, the lowest level of fit.

Agitation occurs when a user believes that the artifact is "more trouble then it is worth" or that it requires more mental energy then it gives. For example, on first encounter, a cell phone may look very complex. Agitation results as a frame of mind when the user worries about the effort needed to learn it and about possibly making embarrassing mistakes.

Major causes of agitation including failure in functionality or usability, psychographic conflict (does not work the particular way users think and feel), pushes against one or more cognitive bias or otherwise creates a condition of cognitive dissonance (holding two or more conflicting beliefs at the same time).

Mismatch with the psychographic profile (cognitive needs) of consumers is a common cause of poor fit and represents a major opportunity for innovation. An example is provided by Zaltman where metaphors are used to discover the deep mental models that consumer's have about hearing aids and how they do not match the marketing and features provided by a typical hearing aid manufacturer. This mismatch between product and psychographics keeps 80% of the people that need the product from using it (Zaltman, 2008).

Tension between functionality and the natural biases in the way we reason, make decisions and socially interact is another major source of low levels of fit. This has been reported well in the behavioral economics literature (Camerer, Loewnstein, Rabin, 2004) especially in terms of the incompatibility between features of savings products and how we actually think and make decisions about the value of future resources.

Agitation as an emotional state releases energy but the energy has a negative valence. As a production factor it would get a negative sign in the mental energy formula reflecting the fact that it does not deliver any immediate benefits but instead consumes mental energy as user must "suffer through it".

The idea of negative valence is critical for cognitive design. We do not want to create any energy, but instead energy that provides a mental benefit or lift. Attribution or the assignment of meaning during interaction with the artifact may have a negative valence too. Meaning is created but it is based on a negative association (e.g. memory of a terrible experience) and because of its negative valence it uses rather than produces energy.

The management of agitation can take constructive and controversial forms. Agitation has been used as an "A" or activating event to get attention in advertising. Real-time monitoring and interventions are used by casinos to make sure agitation does not push high rollers away from the gaming tables (Ayers, 2007). Companies design customer lock-in strategies that create cognitive dissonance in customers that are thinking about leaving or switching products (Lidwell, Holden, Butler, 2003). Agitation can be a feature of training or development programs that are designed to initiate changes in the way we think or instigate the development of deeper social bonds. Programs that trigger and diffuse "hot buttons" in conflict resolution situations make constructive use of extreme forms of agitation.

In cognitive design we seek to eliminate agitation or harness it to produce longer-term and higher-energy outcomes. The factors in the mental energy conversion provide insight into how to achieve this. In summary agitation is caused when:

- The demand factors (mental effort, conscious memory, and vigilance) are relatively high or involve cognitive dissonance caused by conflicting beliefs or a mismatch with the user's psychographic profile or naturalistic reasoning processes.
- The production factors (meaning, visceral factors, incidental processing) are low or involve visceral factors or meaning with a negative valence.

To manage agitation and achieve a superior level of fit we need to assess the demand and production factors within a specific context as well as across the life cycle of the artifact. Following the literature in service design (Bitner, 2007) we define contexts as "moments of truth" or critical interactions where users form the deepest cognitive bonds with artifacts or conversely run the greatest risk of rejecting the artifact. In cognitive design those moments include the first encounter, learning to use the artifact, first real use, routine use and discontinuing use. We must look at energy-in versus energy-out during each moment of as well as across all moments and design for the total customer experience.

**Going From Good to Great Designs**

One successful strategy for improving the cognitive fit of artifacts is to design for the frame of mind described as savoring. Professor Fred Bryant in his landmark book on the subject defines savoring as "attending to, appreciating and enhancing the positive experiences of life" (Bryant, Veroff, 2005). Savoring is a form of cognition amplifies the mental energy we get out of an otherwise positive experience. Bryant describes four possible states of savoring as one goes from luxury to luxuriating, pride to basking, gratitude to thanksgiving and awe to marveling.

In cognitive design terms, savoring is about increasing the level of fit from resonates (luxury, pride, gratitude, awe) to accelerates (luxuriating, basking, thanksgiving, marveling) by adding features and functions that trigger or support savoring during interaction. Fortunately, Bryant's analysis is sufficiently detailed to give designers plenty of clues on how to do this. He details an empirical study of 10 dimensions of savoring and strategies for enhancing it including, prolonging the moment, intensifying the experience and shifting gears into savoring. Tactics for prolonging include reminisce, chaining or redefining the boundaries of the moment, sharing with others after the moment and celebrating. Tactics for intensifying include blocking stimuli that dampens the experience or increasing attention to triggering stimuli. For example, I may eliminate background noise and deeply inhale to more fully savor a meal. Tactics for shifting gears to savor include planning for the experience, anticipating it, comparing to other less positive experiences and relaxing just before the experience.

Each of these tactics produces a unique mental energy-conversion that can be mapped as an ABC diagram similar to Figure 1. In cognitive design the goal is to featurize these tactics in a way that increases the mental net-energy of an interaction. Many of these tactics, for example sharing with others, reminiscing and comparison, build meaning and therefore increase energy-out. For the designer the question becomes – how can I add features to the artifact that naturally stimulate sharing with others, reminiscing and comparative awareness?

One domain where this has been achieved with startling results is online social networks. Such sites, Facebook, Myspace, and Linkedin are an obvious means of sharing with others both retrospectively and in the moment. The "number of friends" feature is a powerful influence on participation. Number of friends can be seen as a badge of honor and may drive pride into basking especially as it produces self congratulations (a dimensions of savoring).

It also drives comparison (a key tactic for savoring) as we see how many friends others have, especially those who we know or have rivalry with. Social networking sites provide a new means of savoring relationships for users with a specific psychographic profile.

Savoring is a treasure trove for the cognitive designer. It is mature enough so that the cognitive science behind it can be directly reflected in tactics for design. Others areas that are just as ripe include for example, prospective memory, cognitive bias, naturalistic decision making, self-regulation, cognition of metaphors and behavioral economics. Much of this treasure remains undiscovered by the design community.

**Measurement**

To bring a sharper point to cognitive design we have developed two types of subjective assessment instruments. The first is a prospective instrument used by designers to assess the level of fit of an artifact or a proposed design. The second is a retrospective instrument used by the consumer to document the actual level of fit. We use or adapt existing cognition-specific instruments (e.g. savoring belief inventory and learning style inventory) to develop psychographic profiles or generate design ideas.

Although the cognitive factors assessment instruments have not been validated by longitudinal studies they have worked well in practice. Dozens of tests in the classroom with graduate students, ten full life-cycle applications and verbal reports from other designers who have used these tools are positive but are far from conclusive.

Current research is focused on a more rigorous study of the predictive value of the six cognitive factors. This includes articulating the model and metrics behind each factor. This will allow us to push beyond subjective assessment and design metaphors to a more scientific approach to cognitive ergonomics.

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