Next-Generation Automated Health Behavior Coaches

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Abstract

Automated health behavior coaches (HBCs) potentially can provide a widely accessible, cost-effective means of promoting health behavior. Coaches are intelligent agents that “converse” with users, offering tailored feedback, advice, and empathy. Research subjects like coaches and comply with target behaviors, but interest and adherence wane over time. More research is needed on next-generation HBCs to improve coaching techniques, enhance user engagement, and extend adherence. However, the necessary technical tools and expertise reside in only a few research labs. In an effort to expand and accelerate research, we are developing an HBC Kit that will extend and specialize our more general Imp™ Kit. We propose 7 innovations for next-generation HBCs, demonstrate them in a lifestyle coach, and characterize authoring with the Imp Kit. We discuss planned extensions for the HBC Kit to enable a larger and more diverse community to create and evaluate a broader range of coaches.

Automated Health Behavior Coaches


Toward this end, researchers are investigating automated health behavior coaches (HBCs) [Bickmore and Giorgino 2006, Bickmore et al 2005, Bickmore and Picard 2005, deRosis et al 2006, Eyck et al 06, Friedman 1998, Hayes-Roth 2008, King and Castro 2007, King et al 2007, Liu and Picard 2005, Miksch 96, Murray et al 2008, Pinto et al 2002, Tate et al 2006]. Prospective advantages include: scalability, lower cost, broad access, comprehensive data capture, reliable performance of theory-based methods, demographic customization, and individual tailoring. The most sophisticated coaches are intelligent agents that “converse” with users, offering tailored feedback, advice, and empathy. Research subjects like coaches and comply with target behaviors, but interest and adherence wane over time. Subjects say they lose motivation because they can’t speak freely and coach dialogue becomes repetitive and boring. More research is needed on next-generation HBCs to improve coaching techniques, enhance user engagement, and extend adherence. However, the necessary technical tools and expertise reside in only a few research labs. In an effort to expand and accelerate research, we are developing an HBC Kit that will extend and specialize our more general Imp™ Character Development Kit [Hayes-Roth et al 1999, Hayes-Roth 2008]. We propose 7 innovations for next-generation HBCs, demonstrate them in a lifestyle coach, and characterize authoring with the Imp Kit. We discuss planned extensions for the HBC Kit to enable a larger and more diverse community to create and evaluate a broader range of coaches.

7 Innovations for Next-Generation Coaches

We propose that next-generation HBCs should manifest the 7 lifelike qualities [Hayes-Roth 2003] described below and illustrated in Harmony, a lifestyle coach. To produce the illustrative interview excerpts, the first author acted as the user, but Harmony generated her own dialogue. Meet Harmony – http://impsvr4.extempo.com/coach/coach.html.

1. Natural Conversation

Coaches should converse naturally with users. Whether speaking aloud or displaying text, they should “sound like” people. Conversely, users should be able to communicate to coaches in free-form natural language. Conversations
should be mixed-initiative, allowing either coach or user to take the lead at any time. As illustrated below, natural conversation creates a more engaging experience and enables more authentic client-centered coaching.

In the first excerpt below, Coach Harmony takes the initiative. Introducing herself, she asks if user Virginia’s current lifestyle is healthy. Recognizing the reply as “no,” she reassures Virginia, motivates her Basic Good Health program, and requests a reaction. She recognizes and appreciates the positive reply. Now Virginia takes the initiative for a series of personal questions, each inspired by a prior exchange. Harmony recognizes and answers each new question, occasionally inserting one of her own (e.g., “How am I doing?”), with follow-up contingent on Virginia’s reply. She honors Virginia’s request to be called Gina. Harmony records all of Gina’s solicited and unsolicited data for later use. Asking if Gina is ready to continue, she recognizes “yes” and retakes the initiative.

**Coach:** Hi Virginia. I’m Harmony, your personal Coach. Tell me, do you currently have a healthy lifestyle, with lots of exercise and healthy eating habits?

**Virginia:** sadly, i do not.

**Coach:** Not a problem, Virginia. The Basic Good Health program might be just right for you. I’ll tailor it to your personal goals and current lifestyle. How does that sound?

**Virginia:** fine

**Coach:** Perfect.

**Virginia:** what's a Coach?

**Coach:** It’s a cute, smart, friendly computer program that helps you change your behavior. Like me, Virginia.

**Virginia:** how smart are you anyway?

**Coach:** That's a deep question, Virginia. Let’s just say, I try to act intelligent. How am I doing?

**Virginia:** pretty good

**Coach:** Thank you. I hope you’ll tell my supervisor.

**Virginia:** who is your supervisor?

**Coach:** Right now, Bella is my supervisor. She is also my maker. I like Bella.

**Virginia:** do you like me?

**Coach:** Definitely, Virginia.

**Virginia:** i like you too

**Coach:** That makes me so happy, Virginia.

**Virginia:** can you call me Gina?

**Coach:** Sure, Gina. Are you ready to continue?

**Gina:** sure

**Coach:** Good. Let’s talk about your goals.

In a later exchange below, Coach Harmony prepares to advise Gina on an initial exercise plan. She requests relevant data and calculates Gina’s BMI. Remembering Gina’s previously mentioned weight loss goal, she offers to help with that. Now Gina takes the initiative, asking if she is too fat to exercise. Harmony informs and encourages Gina to exercise, advises her to consult her doctor, and obtains her commitment. Gina asks about healthy fitness vs. weight. Again, Harmony informs and advises Gina. She retakes the initiative to continue her own interview agenda.

**Coach:** What is your height in inches?

**Gina:** 64

**Coach:** What is your weight in pounds?

**Gina:** 146

**Coach:** 146 pounds. Now I’ll calculate your Body Mass Index, also known as your BMI. Based on your height and weight, Gina, your BMI is 26. That puts you in the overweight range, 25-29.9. I know you want to lose weight, Gina. And I’ll help you.

**Gina:** am i too fat to exercise?

**Coach:** In a word, Gina -- No. Research shows that most people benefit from sensible exercise. Since your BMI is in the overweight range, we’ll start slow and build up your exercise gradually. It also would be a good idea to get your doctor’s opinion. Will you do that?

**Gina:** ok.

**Coach:** Perfect.

**Gina:** what's more important, being fit or being fat?

**Coach:** You know, Gina, from a health perspective, your fitness seems to be more important than how fat you are. A recent study found that fit people live longer than unfit people. In fact, people who are fat and fit live longer than people who are thin and unfit! Of course, we only have the one study so far. And you might have other concerns about your weight. But if you have to choose between dieting to lose weight or exercising to get fit -- I’d say, go for the exercise. Shall we move on, Gina?

**Gina:** why not.

**Coach:** OK. Now let's talk about exercise...

Since the Imp Kit requires little programming, domain experts author the engaging, natural-sounding dialogue and associated logic in these excerpts. They vary dialogue for recurring message semantics via alternate dialogues and parameterized templates. For example, the pattern, #are-you-ready-to #continue, generates alternative wordings for every combination of #parameters. This is done probabilistically or based on run-time conditions. We hypothesize that distinctive voices and normal variability will help coaches pique and sustain user interest.

The Imp Kit allows authors to specify context-sensitive patterns for recognizing free-form natural language input. For example, the pattern, #important #fit #fat, will match synonymous wordings: What's more important fit or fat? Should I focus on fitness or weight loss? Do I have to exercise and diet?—but not similar non-synonymous wordings: What’s harder, fitness or weight loss? Authors create alternative responses to user inputs, ranging from a single line to an interactive exchange, based on run-time conditions. For example, Harmony’s response to Gina’s question “am I too fat to exercise?” takes her BMI into account. If Gina had a normal BMI or Harmony had not yet calculated it, she would give a different response. Authors can place a given pattern and different responses in multiple contexts. For example, Gina frequently says something that matches #yes (e.g., yes, ok, fine, sure, why not), but Harmony’s response varies with the interview
context (e.g., do you have a healthy lifestyle? vs. shall we continue?). Harmony also tracks how many times a user says something that matches a given pattern or set of patterns (e.g., questions about diet), and which responses she has given. Thus, she can vary her responses, to make repeat questions useful, and to inform authors about the popularity of different topics and need for new content.

Free-form user input has other benefits. Giving the illusion of unrestricted input makes the experience more engaging and gratifying. Of course, Harmony does not recognize to unrestricted natural language and a user who persistently tries to trick her will not have a good coaching experience. However, the Imp Kit allows authors to create content for questions and comments that are likely to occur during coaching, including predictable off-topic comments (e.g., I like you, You’re cute/ugly/smart/dumb, How about a date). Harmony is authored to respond politely to such comments, but she has no patience for rudeness. She does not pretend to understand unfamiliar inputs, admits her limitations, and promises to report new inputs to her maker, for inclusion in future releases. In our experience with many applications, updating characters based on user data leads to recognition rates ~90% for reasonable on-topic and off-topic inputs. Free-form input also enhances interactions by letting users ask questions or volunteer data when they wish, without searching lengthy menus, and obviating the need for a coach to solicit questions or data. Thus, authors can discover which topics most interest users and create useful new content. They can discover data users wish to reveal and use that in new coach behavior. They can make interviews adaptive and efficient by skipping questions a user already answered spontaneously.

2. Multi-Faceted Coach Persona

Coaches should have rounded personas, including family, friends, biographies, hobbies, emotions, preferences, knowledge, etc. They should volunteer this information or offer it in responses to user inquiries. Coaches also should display persona in distinctive dialogue “voices,” facial expressions, and body language. This enables a more engaging user experience, more sophisticated interpersonal skills, and a social approach to acquiring user data and cultivating the therapeutic alliance.

In the initial excerpt above, Coach Harmony uses persona content to satisfy the Gina’s natural curiosity: “what’s a Coach,” “how smart are you anyway?”, “who is your supervisor?” When Harmony volunteers, “I like Bella,” she inspires Gina to ask, “do you like me?” When Harmony replies, “Definitely, Virginia,” Gina volunteers useful application feedback, “i like you too.” Gina continues her inquiries in a later excerpt, below. Like many users, she “tests” Harmony, repeatedly asking, “where are you?” Harmony’s author has prepared her to handle this. Later, Harmony uses persona content to mirror Gina’s concern with her weight and uses social exchange techniques to encourage her to share additional data. Then, Harmony uses persona information to mirror Gina’s activity preference, joke a bit, and model healthy lifestyle.

As these excerpts illustrate, multi-faceted coach personas can have several benefits. Coaches are immediately more interesting and engaging. For long-term interactions, users can enjoy “getting to know” their coaches by discovering more and more persona content and even “keeping up” with coaches by accessing periodically available episodic content through questions like: what’s new, how are you, did you go hiking with your boyfriend last week? Persona content allows coaches to use modelling and other persuasion techniques. It enables a coach to make subtle, strategic conversational “offers” to guide users toward content rich topics and inspire them to volunteer data (e.g., I do yoga, I life weights, I’m known for my tango).

Gina: are you a real person?
Coach: I guess you could say I’m a robot -- a software robot, not a physical robot.
Gina: where are you?
Coach: Right here, Gina.
Gina: where are you?
Coach: At your service, Gina.
Gina: where are you?
Coach: You rang?
Gina: where are you?
Coach: Asked and answered, Gina. Try a new question.
...
Coach: Let's talk about your personal health goals, Gina. In the Basic Good Health program, we can focus on your weight, your fitness, or your disease risk. Which one of these is most important to you right now?
Gina: definitely my weight
Coach: Weight. Me too. You know, we all care about our weight and weight control is big business. But 2/3 of adults are still overweight. Personally, I'm happy with my weight right now, so I work on maintaining it. How about you, Gina, do you want to lose, gain, or maintain your weight?
Gina: i really need to lose
Coach: Lose. OK. We'll get to work on that today. All 3 parts of your program -- exercise, eating, and play -- will help you lose weight. We'll also track your weight, so I can tailor your program to achieve your goals. Sound good?
Gina: sure does
Coach: I aim to please, Gina.
...
Coach: What leisure time activity would you like to include in your lifestyle plan, Gina?
Gina: dancing
Coach: You like dancing. Me too, Gina! I'm known for my tango. I only wish girls could lead.
Gina: do you exercise?
Coach: Of course I do, Gina. For cardio, I walk my dog every morning, 15-30 minutes. I also do cardio intervals at the gym, 3 times a week. For strength, I lift weights for an hour, 3 times a week. For flexibility, I do yoga and stretching for 30 minutes, usually after I lift weights. I would like to do more stretching, Gina, but I can't fit it in right now. And, of course, I dance as often as possible. I didn't always exercise this much, but I really enjoy it now.
3. Goal-Oriented, Opportunistic Behavior

Coaches should have flexible behavior: (a) pursue multiple agenda-based goals; (b) vary the order of pursuing goals; (c) pursue their own and user goals; and (d) interrupt and re-enter goal-specific agendas. This produces a more engaging user experience and a more authentic client-centered approach. In the first excerpt above, Harmony begins a 10-step agenda to introduce herself, describe the Basic Good Health program, and acquire data. After step 7, Gina interrupts, “how smart are you anyway?” Harmony responds with a nested 3-step agenda (“That's a deep question, Virginia. Let’s say, I try to act intelligent. How am I doing?”), whose last step has contingent 2-step agenda based on a user’s response (#good: “Thank you. I hope you’ll tell my supervisor.” #bad: “I’m sorry to hear that…”). After several exchanges, Harmony obtains Gina’s agreement to continue and re-enters the top agenda, step 8.

The Imp Kit has several mechanisms for goal-directed, opportunistic behavior. Authors can construct nested goal-specific agendas and specify transition conditions. They can use different speech acts. For example, a “story” is a sequence of speech acts (e.g., statement, open question, yes-no question) that may be interrupted and re-entered if the interruption does not last longer than a specifiable limit. All agendas and speech acts are interrupted at run-time whenever the user provides a spontaneous input – unless the author specifies a non-interruptible speech act.

4. Variable, Context-Sensitive Behavior

Coaches should display variability in their use of words, phrases, exchanges, expressions, and body language. This enables a more lifelike coach, a more engaging user experience, and more sustainable user interest. The Imp Kit allows authors to create alternate behaviors in a hierarchy of interaction contexts and specify how to choose among them at run-time based on probabilities, priorities, discrete conditions, or continuous variables. This produces behavior that is pleasantly predictable, delightfully surprising, and useful in achieving application goals.

Harmony varies language by instantiating “word groups” at run-time. For example, in “How about you, #user, do you want to lose, gain, or maintain your weight?” she may instantiate #user with the user’s name. She might use a pet name, such as “my friend” or “girlfriend.” She modifies #user on request, for example: “call me Gina?” or “don’t call me buddy.” Some word groups include phrases. For example, #validate-user-choice includes: “Me too, #user!” “Same here, #user!” and “Likewise!”

Harmony uses a matrix of mood-specific actions, for selection at run-time. For example, she has several alternate “explain” gestures for her usual mood, “neutral.” She has a smaller number of explain gestures for other moods, such as, “encouraging” or “impatient.” When Harmony explains something, she selects an explain action from the explain cell representing her current mood.

At a higher level, Harmony can choose among alternative dialogue lines or even agendas. In one of the excerpts above, she gives a meaningful series of different responses to the user’s repetition of the question, “where are you?” Similarly, she can choose and tailor her behavior based on other variables including: user data (e.g., level of achievement of weekly targets), user moods (e.g., self-efficacy encouraged by the coach and reflected in user dialogue), the coach’s own moods (e.g., chattiness responsive to user feedback), and the coach-user relationship (e.g., strength of the therapeutic alliance cultivated by the coach and reflected in user dialogue).

5. Global Adaptation to User Conditions

Coaches should monitor and adapt to user-specific conditions. For example, Coach Harmony should behave differently depending on whether a user met last week’s exercise targets or is in a hurry to finish today’s consultation. When accommodating a user’s preferred topic sequence, she should track topics to insure complete coverage and avoid repetition. This enables more tailored advice, personalized coaching, and a more engaging and natural user experience. In the excerpt below, Harmony uses 3 conditions to personalize her comments about exercise benefits: Gina’s top-goal is weight management, gender is female, and age is under 40. In the next excerpt, Harmony uses 3 other conditions to tailor her advice: Gina is young, does not exercise, and has low self-efficacy.

Coach: Gina, research shows that exercise contributes to all aspects of basic good health. It builds physical fitness -- a healthy heart and lungs, strong muscles, and flexibility. It reduces risks for diabetes, cancer, heart disease, and other serious diseases. And it is a powerful tool for weight management. Your top goal, Gina. But that's not all. Exercise can improve your sleep, your mood, and even your appearance. Which of these 3 extra benefits would be most valuable to you?

Gina: I would really like to improve my mood

Coach: Mood. I hear you, Gina. In fact, I hear that from a lot of women. Especially young women like you. Gina, we’re going to try to improve your mood with exercise, but you might want to discuss concerns about mood with your doctor. Will you do that?

…

Coach: We're going to build your walking program one step at a time, Gina. This week, we'll set your target days, minutes, and intensity, based on age, BMI, and current exercise. In the future, we'll update your targets based on your progress. I'll always give you choices between higher and lower targets. Since you're not too confident about making lifestyle changes, feel free to choose lower targets. Since you have not been exercising at all, Gina, I suggest a target of 2 or 3 days this week. Which would you prefer?

6. Continuous Dynamic Moods

Coaches should model and adapt to users’ and their own dynamic moods. For example, Harmony might infer from a user’s behavior that he or she is becoming more or less
curious, ambitious, self-efficacious, or compliant. The coach herself might become more or less chatty, educational, or reassuring. This enables a more lifelike and engaging user experience, more tailored coaching advice, and a more personalized coaching style. The Imp Kit (a) defines any number of moods as potentially overlapping n-dimensional volumes in a space of underlying continuous variables (e.g., arousal, valence, attraction); (b) automatically calculates the user’s or coach’s “current mood” as a point in the space, based on qualitative shifts (e.g., more/less, a bit more/less) on particular moods, induced by the occurrence of specific events (e.g., expression of praise or doubt); and (c) uses current moods (e.g., very curious, not cooperative) to select or refine alternative behaviors or dialogues at run time. It provides a methodology for authoring moods, dimensions, and utilization, in order to create desired coach behavior dynamics and adapt to important changes in user state.

In the initial excerpt above, Harmony assesses Gina as “a bit more personally-curious” (compared to her prior state) after each persona inquiry and “a bit more socially-responsive” after they discuss liking one another. Later, in the discussion of leisure activities, she plays into Gina’s now “highly personally-curious” mood by offering personal information about her tango dancing. Harmony assesses Gina as “a bit more educationally-curious” after she asks “am I too fat to exercise” and “what’s more important, fit or fat?” She offers information in her response to the first question and a more detailed comment in her response to the second one. These same observations lead Harmony to assess Gina as “a bit more weight-conscious.” But the 2 moods have different meanings and implications, due to their defining dimensions. A change in weight-consciousness impacts moods that share its “self-esteem” dimension. A change in educationally-curiousness impacts moods that share its “curiosity” dimension.

Harmony herself becomes increasingly impatient when Gina repeatedly asks, “where are you?” If Gina were to repeat her question a 5th time or immediately start repeating another question, Harmony would become even more impatient and reply testily. Alternatively, since Gina moves on, Harmony’s mood rapidly regresses to neutral, as the author gave impatience a high regression co-efficient.

7. Long-Term Memory

Coaches should build and use a comprehensive, persistent user database of factual, temporal, and episodic data. This enables more tailored coaching advice, more personalized coaching services, richer user experiences, and more enduring social bonds. The Imp Kit permits insertion of database read/write expressions anywhere in coach dialogue or other behavior, enabling them to elicit, notice, and reincorporate useful data. In the illustrative intake interview, Harmony acquires the following data, uses it during the interview, and stores it for use in future visits.

**User ID:** name, nickname, email

**Intake-Only Data**

**Persistent personal data:** gender, birthdate, height

**Dynamic personal data:** weight, bmi

**Initial goals:** top goal, specific goal, other desired benefits

**Initial attitudes:** motivation to improve health, self-efficacy to change habits, utility of coach

**Initial opinions/knowledge:** exercise importance & amount needed, diet importance & amount of fruits & vegetables needed, exercise drop-out rates, etc.

**Initial lifestyle habits:** general, cardio, diet, fruit & vegetable consumption

**Regularly Updated Session Data**

**Preferences:** walking, time of day, place, play activity

**Comments:** walking frequency, duration, intensity; fruits & vegetables #/day; play activity

**Ambition:** lower vs. higher target options chosen

**Post-planning attitudes:** self-efficacy for exercise, eating, play, overall

**Post-planning comment:** high, medium, low

**Compliance:** discuss health matters with doctor, try recommended exercise, diet, play, log lifestyle data, accept email reminders, …

**Persona questions/comments & coach responses:** …

**Persona info volunteered by coach:** …

**Education questions/comments & coach responses:** …

**Education info offered by coach:** …

**Attitudes/interests in coaching:** frequency, desired type…

**Specific feedback to coach:** likes coach, helpful, smart, …

**Exit values for Boolean conditions:** …

**Exit values for continuous moods:** …

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**Planned Extensions for the HBC Kit**

The Imp™ Kit provides tools for building, deploying, and evaluating a great variety of interactive characters:

* Imp Author enables content experts and writers to create vivid characters with well-defined expertise.

* Imp APIs support integration with alternate animation, voice, databases, and other applications and technologies.

* Imp Engine supports hundreds of concurrent users per CPU, with round robin scheduling across multiple CPUs and graceful degradation on hardware failure.

* Imp Admin supports application management and online modification of character content and behavior.

* Imp Analysis produces specifiable statistical reports from annotated transcripts of user-character interactions.

* Imp Online allows authors to create and test characters on desk-top computers, then upload them for deployment, monitoring, and data collection on a hosted site.

Basically, Imp Kit automates programming of interactive characters, enabling domain experts to author context-sensitive dialogue, menu-based pre-conditions and moods, etc. It has been used by dozens of non-technical people with degrees in English, Drama, Health, Education, Psychology, Communications, etc. They made commercial characters (e.g., Virtual Jack™ canine host for Petopia; Virtual Mr. Clean™ household cleaning advisor for Procter & Gamble) and research characters (e.g., virtual coach and patients to train clinical interviewing; various student
projects in the first author’s courses at Stanford). Besides out own team, current authors include: Dr. Eva Hudlicka’s group at Psychometrix, building a virtual coach for meditation; and Dr. Gail D’Onofrio’s group at Yale Medical School, building a virtual coach and patients for brief intervention. Based on this experience, we believe the Imp Kit would empower a large and diverse community of researchers to build and evaluate a great variety of HBCs.

To further facilitate and expand research, we plan to extend and specialize the Imp Kit to make an HBC Kit. We will use a component-based approach to building large and sophisticated intelligent agents, which we previously developed and demonstrated in office robots and medical monitoring agents (Hayes-Roth et al 1996). The HBC Kit will introduce facilities for creating, sharing, and reusing customizable HBC content components, such as:

**Persona Topics.** Many HBCs can use vivid persona topics to attract, engage, persuade, retain, and benefit users and to be tailored to user preferences and demographics (Maldonado and Hayes-Roth 2004, Rousseau and Hayes-Roth 1997). For example, Harmony’s persona includes recognition patterns and responses for several kinds of user input: **personal:** How old are you? Where do you live? Do you have a boyfriend? Are you real? **praise-insult:** You are (not) cute. I (don’t) like you. You are (not) smart. **lifestyle:** Do you exercise? How do you feel about your weight? What is your favorite play activity? **interaction:** Go faster/slower. Can I ask questions? Call me **nickname**.

**Health Topics.** Many HBCs must recognize and respond to common user inputs on health topics. For example, Harmony’s health topics include eating, exercise, fitness, weight management, disease prevention, mood, sleep, etc.

**Coaching Topics.** Most HBCs must recognize and respond to questions about coaching, such as: Do I need a coach? How long will you coach me? What is your style?

**Coach Roles.** HBCs have well-defined coach roles, often based on particular theoretical frameworks, which structure their interactions with users. Role content includes: nested agendas; step-by-step interaction logic, dialogue, and context-sensitive keyword patterns; data read/write specs, etc. It may include higher-order structure, such as Harmony’s monitoring and interacting with users as they move from preparation to action to maintenance stages.

**Interview Segments.** Many HBCs will need interview segments (interactive logic, dialogue, context-sensitive keywords) to achieve common objectives. Harmony has interview segments to acquire a user’s attitudes, general and specific health goals, exercise knowledge, personal data, current exercise habits, health problems, etc.

**Empathic Encouragement.** Many HBCs will beneficially use empathic behavior to build trust and the therapeutic alliance. For example, when a user mentions a problem or concern, Harmony offers sympathetic advice or assistance.

We plan to seed the HBC library with components developed in our own work and to invite other researchers to contribute components from their work. We will create **configuration tools** to search and select components for use in new coaches. At one extreme, an author might select a complete model coach, such as Harmony, and customize it with a new persona or new objectives for flexibility or strength, rather than cardiac fitness. At the other extreme, an author might build a new HBC, but reuse Harmony’s health topics. We also will specialize Imp Analysis tools for variables and contrasts of interest. Benefits include:

* Researchers who currently do not have access to needed tools and expertise can build and evaluate HBCs.
* Researchers can create better HBCs faster by reusing proven components developed by their colleagues.
* Researchers can rigorously control variations among experimental HBCs by component selection.
* Researchers can independently vary HBC function, persona, demographics, social skills, etc.
* Researchers can independently vary animation, typed vs. voice, freeform vs. menu-based, desktop vs. hand-held, etc.
* Researchers can verify and control implementation of alternative intervention protocols.
* Researchers can use automatic reports to monitor HBCs, detect errors, make improvements, and update online.
* Researchers will automatically get reports on standard variables, e.g.: engagement, adherence, efficacy, change stage, working alliance, social bond, satisfaction.
* Meta-analyses will be enabled by use of stored datasets.

We would be happy to discuss opportunities for other researchers to use the Imp Kit in their own HBC projects now and to participate in development and use of the prospective HBC Kit.

**References**


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