

Measuring the Process of Behavioral Decision-Making: A Preliminary Study on Visualizing and Quantitizing the Feedback Loop

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Abstract

In the social and behavioral sciences, both quantitative and qualitative researchers have raised concerns about measuring phenomena as they exist in the actual world because of the issue of the replicability of findings and results or the so-called crisis in psychology. Their concerns apply specifically to person-specific situational flexibility or the behavioral flexibility that an individual can display across situations. The purpose of this study was to explore the measurement of the person-specific process of behavioral decision-making in the situation of complex learning and problem solving by employing mixed method research integrated closed- and open-ended questions. Two studies were conducted, one involving the re-analysis of previously collected data, and the other involving a case study to bring to the fore the process of behavioral decision-making. The first study showed the format for suitable integrated open-ended questions. The case study showed how to capture the behavioral decision-making process via timescales and feedback loops. It was concluded that flexibility in the process of behavioral decision-making as noticed by the participant could be visualized and quantitized to enable data-analysis.

Keywords: personal characteristics, flexibility, self-identity, timescales, feedback loops

Introduction: The *Process* of Behavioral Decision-Making

Researchers in the social and behavioral sciences have raised concerns about the study of individual behavioral flexibility in situations to maintain behavioral balance (e.g., balancing short-term and long-term learning: David et al., 2024; balancing positive and negative thoughts and emotions for health: Kashdan, 2010; balancing emotion and well-being: Klein et al., 2023). The individual's behavioral reactions to the situation involve an interaction between the body and brain, both of which require time to process the incoming information from the external environment, which means that an individual has to decide on behaviorally appropriate reactions to the changing situation-across-time by dealing with the gaps in observed and interpreted environmental information. Situations continuously change across time, in varied degrees of change, and humans adapt to these changes by interpreting the situation and reacting flexibly, to a certain degree, in order to maintain a balance in behavior that agrees with their self-identity (Hagger & Chatzisarantis, 2006; Verplanken & Orbell, 2019) as a necessity for functioning as a whole (Lomas, 2021; Yildirim et al., 2022). It seems that the maintaining of behavioral balance in situations is enabled by the *process* of behavioral decision-making of the individual person in a situation by having the ability to choose between habitual and alternative behavioral reactions to certain situational aspects (Van Velzen, 2025). The process of behavioral decision-making is a dynamic one because it is influenced by personal characteristics and situational changes across time as they are taking place in the actual world.

For example, late-adolescent students who participated in a research study (Van Velzen, 2024) were grouped into approximately similar kinds of learners based on person-specific intra-individual raw data that had been obtained via integrated open-ended questions on learning behavior. The groups of students showed their similarity in connecting certain learning techniques to certain learning situations and task demands, in that the data informed about their similarities regarding their knowledge of who they are in a learning situation via preferred or habitual learning behavior. However, imagine that the researcher invites these students to another research study where the students receive a learning task that has some challenges. Will the students of a group now react similarly to this situation, for instance, by making the same learning-behavioral decisions at the same time to counter the learning-task challenge? Most likely, they will not because they can vary in deciding on *when* and *why* to abandon the preferred behavior in favor of new or alternative behavior that is in line with one's self-identity in the face of challenges. In the actual learning situation there can be individual variation regarding the decision moments in learning behavior, which is irrespective of having similar preferred or habitual learning techniques with other students. This raises the question of how persons perform the dynamic ability of deciding on appropriate behavior to situations that can change across time. Research suggests that behavioral decision-making requires timescales for situation interpretation and feedback loops for taking into account near-previous behavior in behavioral decision-making (Van Velzen, 2025; 2025a). See Figure 1.

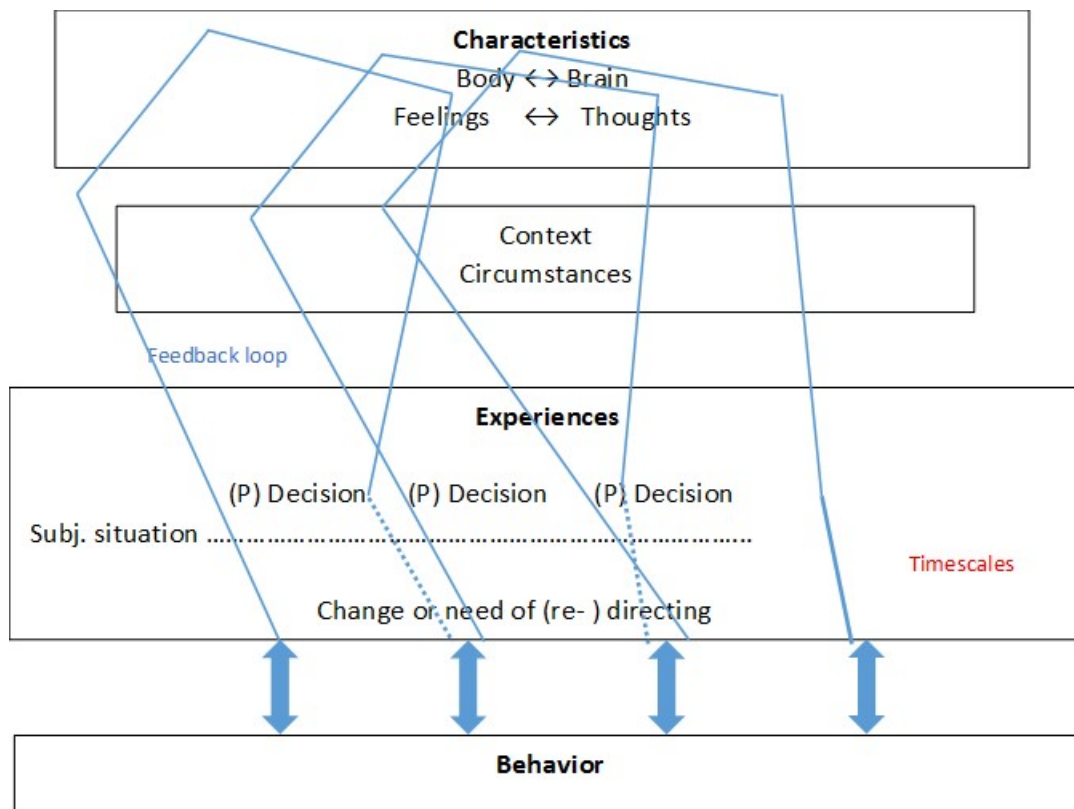


Figure 1. Theoretical framework of the behavioral decision-making process (Van Velzen, 2025).

In Figure 1, timescales refer to situation interpretation because the subjective situation is relative to the observer, hence, in comprehending the situation and oneself as a whole, the observer will observe and focus on some situational features more intensely than on other situational features. Feedback loops refer to enabling that previously interpreted information remains activated within the individual's mental processing (i.e., working memory) for the purpose of producing well-considered future behavior. The interconnected and continuing nature of the behavioral decision-making process in Figure 1 can raise the question of how to measure this process via a data-collection instrument. *The aim* of this study was to explore the suitability of mixed method research integrated closed- and open-ended questions to assess the person-specific process of behavioral decision-making of late-adolescent and adult students in order for them to maintain behavioral balance in learning and problem solving.

Integrated Open-Ended Questions

Open-ended questions enable individuals to respond descriptively, in that each responder can state his or her own experiences and meanings because one is allowed to respond in one's own words. As such, open-ended questions are exploratory in nature and they collect qualitative data. The advantage of open-ended questions being exploratory is that they are suitable when variables are not well defined. Typically, not-well defined variables are present in research studies when measurements include the person, context, phenomenon, and process across time, which is often the reality in the social and behavioral sciences (Cronbach, 2004; Molenaar, 2004; Van Velzen, 2023). The person in the situation faces the context as a result of contextual features coming forth from various sources, and this can lead to the observing of a variation of individual (a) situational interpretations, (b) deviating preferences across time, and (c) distractions and uncertainties (Van Velzen, 2025a). The individual also requires time to mentally process and make inferences about contextual features so that it agrees with himself or herself as the individual that he or she is. The individual has to work with timescales to interpret and evaluate certain aspects of the situation that are open for observation to him or her, of which some are more intensely observed than others are. This means that flexibility is a necessity to maintain behavioral balance when the continuing context makes unexpected changes during the unobserved periods of time.

In a similar vein regarding personality theories, Hecht et al. (2022) pointed out that research that includes the person, context, phenomenon, and process has to bridge the seemingly contrasting positions of stable traits, variable states and events across situations, and flexible personal adaptations. Hecht et al. (2022) argued that data could reveal (a) between-person effects, in that some variables can be shared by more than one individual, (b) contemporaneous effects, for instance, typing speed and typing accuracy can be positively related at the between-person level, but negatively related at the within-person level, (c) autoregressive effects, or personal characteristics that can change across time, not necessarily as a random fluctuation, but depending on personal states, such as mood, and (d) cross-lagged effects, in that personal and situational circumstances can change across time. Therefore, open-ended questions are considered to be suitable to measure the person and flexibility in reacting to the situation because the individual interprets the situation subjectively, which will affect the individual's experiences, knowledge, thoughts, and feelings, and it may require alternative behavior or deviating from typical behavior in order to react appropriately (Rauthmann et al., 2015; Van Velzen, 2025a).

However, open-ended questions also have some serious disadvantages. First, it can be more difficult for persons to respond to open-ended questions in comparison to closed-ended rating-scale and select-choice questions. That is, having to come up with a response to an open-ended question and describe one's experiences, thoughts, and feelings is more difficult to do than selecting a response from predefined categories. Also, combining open- and closed-ended questions may not improve responding in terms of reliability because open- and closed-ended questions do not measure the same thing, and consolidated or created data sets hardly resolved this matter (Van Velzen, 2018). For example, (late-) adolescent students are able to describe their metacognitive knowledge due to engaging in self-reflective thinking (Brown, 1987; Mudrik et al., 2014; Van Velzen, 2017a). Van Velzen (2018) found a small and non-significant correlation coefficient ($r_s = .17$) between the closed-ended questions (e.g., "I know if I can summarize subject matter: no, sometimes, neutral, often, and always") and their related open-ended questions (e.g., "because I focus on . . ."). That is, the closed-ended responses consisted mostly of "often and always" ratings, but most open-ended responses showed inexplicit descriptions, showing the unsuitability of employing both kind of questions to study metacognitive knowledge. However, several related or integrated open-ended questions did provide for statistically significant correlations.

To solve this issue of the incompatibility between related closed- and open-ended questions, Van Velzen (2021a) also focused on supplementary integrated open-ended questions that consisted of open-ended questions that inquired about a specific subject and that belonged together because they build forth on one another: "If I receive a learning task for which I need to . . . and . . . and . . ., then I will . . . because . . ., and I will . . ., if . . . because . . ." This kind of supplementary integrated open-ended question gives each student time to overthink the question in more detail and respond in their own words. To check if the provided response is true to themselves, each student also had to give an example of a personal experience. Noticeably, students need to include the context to respond to the supplementary integrated open-ended questions as it is relevant to describe experiences and knowledge (see also Study 1).

Second, it can be difficult for persons to provide for in-depth responses and to present their experiences and knowledge about behavior and decision-making in an organized manner. For example, Luciano (2017) explains, via a review of experimental research on behavior, that someone's behavior, although it is familiar, can be difficult to put down in writing because one's experiences become aware to oneself in a flow of thoughts and feelings that are related to the subjective interpretation of the present context as it is functional for the person in that situation (Van Velzen, 2023). Luciano pointed out two kinds of variability in person-situation responses, namely generating novel behavior and the impact of one behavior on to the next. Further experimental analysis of novel behavior and the impact of previous behavior showed the importance of maintaining coherence, in that someone needs behavioral balance in terms of one's behavior being in agreement with one's self-identity. Hence, to support the person in responding in an in-depth and organized manner, open-ended questions can include prompts that refer to the variability in the situation, as long as these prompts do not steer the person in any way to a certain direction (Pawson & Tilley, 2014).

To summarize, integrated open-ended questions (Van Velzen, 2018) were considered to be more suitable than another data-collection instrument for this study because (a) integrated open-ended questions have *individuals* respond in their own words, thereby not only enabling them to bring forth that which is most important to them, but also (b) to bring forth certain person-in-the-situation features that the

researcher may not have included as an item because it is yet an unknown feature in the research theory (i.e., emerging variable), and (c) it is a more objective qualitative data-collection instrument than, for instance, interviews, discussion, and panel groups are because the individual can respond independently. When having to collect also quantitative data (e.g., timescales), data collection can consist of mixed method research integrated closed- and open-ended questions.

Theoretical Framework for Learning and Problem-Solving

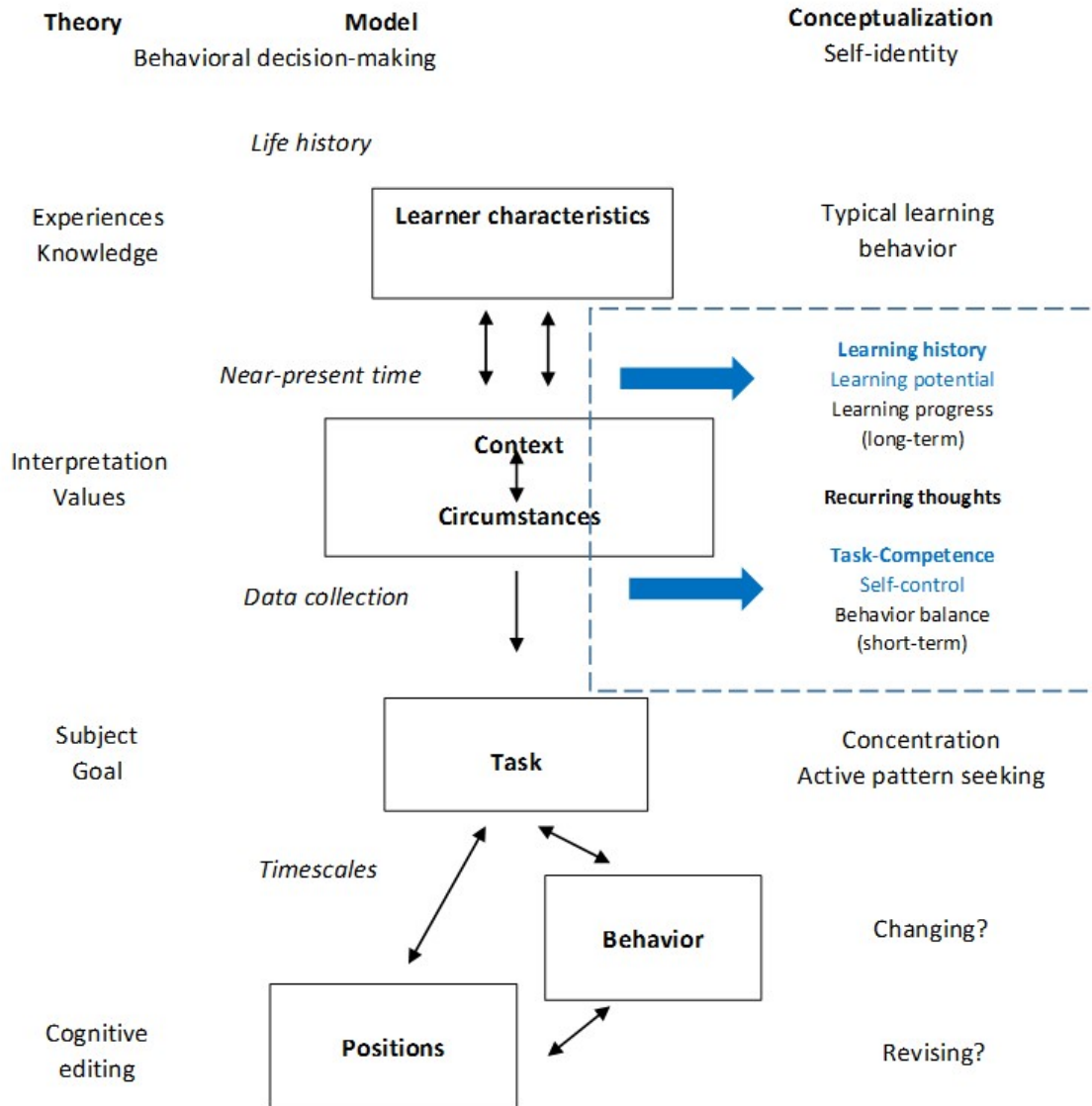


Figure 2. Theoretical framework of student behavioral decision-making process. Learning (e.g., history) also can be problem solving (e.g., history).

Figure 2 shows how behavioral decision-making is conceptualized via self-identity. As aforementioned, experiencing behavioral imbalances can arise when the

subjectively interpreted situational changes (i.e., context) do not agree with one's self-identity. Self-identity refers to the person striving to be in line with one's typical thoughts, feelings, and behavior that are based on one's memorized experiences or knowledge (see also Lomas, 2021; Yildirim et al., 2022). Behavioral imbalances can also arise when situational changes require novel kinds of behavior (e.g., probing and abrupt changes: Van Velzen, 2022), which is guided by one's personal history in relation to the presently experienced level of task difficulty. Someone's personal history is stored in long-term memory, mostly as contextualized facts (i.e., a thing done) and rules. Personal history plays a primal role in deciding on how to react to situational changes as it guides the overall subjective interpretation of experiencing the impact of one's behavior (e.g., learning progress, or not, during studying and memorizing in relation to one's known learning potential: "I could have done better") and personal and situational circumstances (i.e., recurring or preoccupying thoughts that interfere with how someone could process information cognitively: Van Velzen, 2021b).

Next, behavioral imbalance also can arise due to experiencing task difficulty (Gan et al., 2020) in relation to performance competence (i.e., thinking and feeling confident versus uncertain about performing a task: Lerner et al., 2009; Tulaskar & Turunen, 2022), which can be balanced via one's power of concentration (i.e., focusing on attention control versus having distractions: Nobre & Van Ede, 2018; Schmidt, 2020) and active pattern seeking or making sense of information by integrating it to knowledge sensibly (Van Velzen, 2025). Uncertainty refers to thoughts and feelings that arise when that which is happening in the situation is undetermined, which can lead to behavior that consists of searching for clarifications, doing nothing, considering innovative behavior, and displaying awkward (i.e., not one's usual self) behavior. Noticeably, the definitions of the theoretical framework in Figure 2 are preliminary in anticipation of future empirical research studies on person-situation behavioral decision-making regarding learning and problem solving and how and why the feedback loops and timescales of Figure 1 can be incorporated into the theoretical framework of Figure 2.

The presented theoretical frameworks of Figure 1 and Figure 2 for situations that require flexibility in behavioral decision-making has led to the following overall research question for the studies in this article: "How to measure person-specific characteristics and situational interpretations in a specified actual situation via mixed method research integrated closed- and open-ended questions in order to obtain an understanding about when and why the individual decides to make changes in his or her learning and problem-solving behavior to maintain behavioral balance?" To answer this research question there are two preliminary studies. The first study involves a global re-analysis of existing data regarding the suitability of integrated open-ended questions: "Can integrated open-ended questions about learning and problem solving inform about situation-specific changes in behavioral decision-making by including feedback loops and timescales (Figure 1), and context and circumstances (Figure 2)?" The second study consists of a case study to obtain insights about how to bring to the surface the individual's timescales and feedback loops via mixed method research integrated closed and open-ended questions: "What should be the features of the integrated open-ended questions in relation to closed-ended questions in order to collect information about person-specific flexibility in learning and problem-solving behavioral decision-making via timescales and feedback loops?"

Study 1: Data Re-Analysis

Data from previous studies (Van Velzen, 2017a) with integrated open-ended questions were re-analyzed to examine their merits for the study of the process of behavioral decision-making. The subject of the studies was understanding the concept of metacognitive knowledge (MCK) or long-term memory of effective learning (i.e., study and memorization) techniques and problem-solving strategies.

Method

Participants. There were three groups of participants (see Table 1). Group A2 is a selected sample of Group A1. Participation was established via research calls (i.e., emails and flyers), and all participants had volunteered by giving a written consent.

Table 1

Participants for Study 1

Group	<i>n</i>	men	women	?	<i>M</i> _{age} (range)	School	Subject/sciences
A1	316	122	188	6	17 (16-18)	Senior high	All
	132	8	117	7	19 (18-20)	University	Social and behavioral
A2	72	13	59	0	18 (18)	Senior high	Explicit MCK
B	53	30	23	0	16 (15-17)	Senior high	L1-language
C	21	15	6	0	20 (18-27)	University	Mathematics

Note. ? = unknown sex. Range = age in years. All senior high school students were Grade 11. All university students were first years. Explicit MCK = qualitative high level of responding. L1-language = mother-tongue language.

Procedure. Data collection consisted of introducing the participants during a collective assembling (i.e., per classroom and mentor group) by explaining the task, the importance of receiving comprehensive responses, and guarantying the anonymity of the results. The researcher and either a familiar teacher or mentor chaired the data-collection sessions. The researcher was allowed to respond to participant questions by reformulating the given information and encouraging the responding in one's own words, but without directing the participants in any manner.

The participants of Group A received one of three kinds of integrated open-ended questions (see Table 2), each kind having a different subject (i.e., general knowledge of learning or developing cognitive knowledge, learning-task demands, and oneself as a learner via stable learner characteristics and overall personal strengths and weaknesses in studying and memorizing). Each kind of integrated open-ended question consisted of six related open-ended questions. The participants responded individually until they were finished (i.e., unlimited time to respond).

The participants of Group B (see Table 2) received three kinds of complex non-routine reasoning problems (i.e., standard logic, comprehension, and linguistic) and integrated open-ended questions that required a solution via a prescribed procedure (i.e., "Please, first read the problem carefully and answer the first three questions, then read the problem again and respond to the next three questions; finally, solve the problem and respond to the final question").

The participants of Group C (see Table 2) first received the learning task, which they studied for a few minutes, and then the task of making an effective planning. Next, they learned the information of the learning task and after ten minutes, they had to return the learning task information to the researcher. The learning task was a description of a fictive island inhabitants' arithmetic system (i.e., based on unfamiliar symbols, such as \square and Δ , and proportions), and vocabulary (e.g., raski means fish). After this, the participants had to respond to two open-ended questions and solve the problem-solving tasks of "Please, translate the sentence and calculate how many fish there are for each inhabitant."

Table 2

Summary of the Kind of Questions Per Group of Participants

Group	Subject/ Sub-task	Question	Time limit
A	Learning	"I know if I understand the essence of subject matter, because I focus on . . ."	No
	Task demands	"I know if a learning task is difficult or easy, because difficult tasks include . . . and easy tasks include . . ."	No
	Oneself as a learner	"I know my reasons for doing homework extensively or superficially, because I study extensively when . . . and superficially . . ."	No
B	Problem understanding	"What is the purpose of this task?;" "Which components do you have to take into account?;" "What can be an obstacle?"	No
	Selection of strategy	"Describe the problem-solving strategy that you have decided on;" "Why are you going to use this problem-solving strategy?;" "I will focus on . . . because . . ."	No
	Retrospective self-reflection	"Was the selected problem-solving strategy effective?"	No
C	Effective plan	"You have two minutes to read the learning task in order to make an effective planning. Which study and memorization techniques do you intend to use and, please, explain why?"	yes
	Learning information	"You have ten minutes to learn the information, after which you will receive other questions. Did you consider or actually changed your plan during learning and, please, explain why?"	yes
	Solving problem	"Please, return the learning task to the researcher and then translate the sentence on the paper received next."	no
	Fictive situation	"Imagine that to fully understand the arithmetic system of the learning task, you now have to study a book of 300 pages. Which study- and memorization techniques will you use and, please, explain why?"	no

Table 2 shows that the questions for Group A inquired about their *knowledge* (i.e., long-term memory) regarding effective learning in general. The questions for Group B inquired about effective problem-solving strategies regarding the completely *unfamiliar task situation* of complex non-routine problem solving. The questions for Group C inquired about four tasks (i.e., learning and problem solving) to examine if there were *changes* in their behavioral decision-making in a difficult, but relatively familiar, task situation.

The research design for all three groups was the one-group one-observation design (i.e., no treatment, pretest, and posttest: Group A had one questionnaire and the groups B and C had more than one task and question) because little was known about late-adolescent students' knowledge of effective learning techniques, and for group B and group C problem-solving strategies, and how this can change during learning and problem solving.

Data Analysis. The data analysis was a re-analysis or a reinterpretation of the responses because originally the data were collected for other studies (i.e., Group A1 see Van Velzen, 2016, 2018; Group A2 see Van Velzen, 2013, 2016; Group B see Van Velzen, 2017a, 2017b; Group C see Van Velzen, 2017a, Chapter 5). For this study, new content analyses were performed and it has not been published elsewhere. Data re-analysis consisted of searching for the meaning of the concepts of the theoretical frameworks of Figure 1 and Figure 2 regarding behavioral decision-making.

Results

Table 3

Comparing the Results of Group A (N = 448) in Relation to Group B (N = 72)

Group	Result	Truncated example response
A1	General if-then	"To understand subject matter, I reread information; to memorize subject matter, I repeat information."
A2	Framework concepts	<i>Pattern seeking:</i> ". . . associate subject matter to prior knowledge;" ". . . when subject matter is logically organized and has a clear line of reasoning." <i>Interest:</i> "I study thoroughly unless I am not interested in the subject matter." <i>Concentration:</i> "To understand subject matter, I translate it into my own words, even though it takes a lot of time and concentration." <i>Feelings:</i> "When I feel confident about learning, I try different learning techniques;" "When I have not enough time to study, I get stressed and can hardly concentrate;" "I can remember things for a very long time when I have . . . enjoyed them."
B	General decisions	<i>Trying out/trial-and-error:</i> "I will try things out;" "See what comes to mind." <i>Resorting to typical behavior:</i> "I will write down everything because I always do it like this;" "I will try to get an overview."
	Framework concepts	<i>Feelings:</i> "I solved it quickly and, hence, I did not become stressed out;" "I like these tasks."

In Table 3, comparing the responses between Group A and Group B showed that inquiring about MCK (group A) versus employing MCK in the actual situation (Group B) provided for general and certain if-then (i.e., habitual) rules versus specific and uncertain (e.g., trial-and-error) situational information, respectively. For Group A, the responses suggested the existence of typical well-known behavior for specified learning tasks and situations. The responses of Group B suggested trying out (typical) behavior in the unfamiliar task situation. It was concluded that the integrated open-ended questions could inform about general and habitual MCK as it is employed in certain and uncertain situations.

The concepts of the theoretical framework of Figure 2 were found mostly in the explicit-MCK responses of Group B, but there were few of them. However, none of the responses informed about feedback loops, timescales, context, and circumstances (i.e., Figure 1 and Figure 2) regarding behavioral decision-making. It was concluded that it was unclear whether the non-routine learning and problem-solving tasks and the employed integrated open-ended questions can elicit responses about these concepts.

Comparing the responses between Groups B and Group C, to understand better the task and situational features and behavioral decision-making in the actual situation, showed that the responses in Group B primarily focused on obtaining the solution and, thereby, it was task specific rather than situation specific. The kind of responses of Group B on the final retrospective self-reflection question (“Was the selected problem-solving strategy effective?”) per solved problem and varying response of each participant ($n = 34$) were (a) confirmative ($n = 23$: “Yes, it worked” and “I found a solution”), (b) well-organized ($n = 5$: “The strategy gave an overview of the problem;” “It helped to work in an organized manner), (c) step-wise ($n = 1$: “I worked from simple to complex”), (d) negative ($n = 8$: “I did not have a strategy;” “I could not find a strategy”), and (e) un-solved ($n = 16$: “I could not find a solution”). Therefore, only $n = 6$ responses included actual strategic problem-solving responses (i.e., well-organized, step-wise strategies). Comparing these results to the results of Group C, where all participants made an effective plan (see Table 4) showed that a doable kind of complex non-routine task is important when employing integrated open-ended questions about effective learning techniques and problem-solving strategies.

Table 4

Summary of the Content Analysis for Group C: Responses Per Sub-Task or Decision

Sub-task	Correct	Truncated example response
Change of plan Yes. Logic/why.	Yes	“I noticed that the colors had a pattern, it helped me to memorize. So, I had more time to drill the words.”
Yes. Only considered.	No	“I considered if I should also write down the words I wanted to memorize, but then I did not do it.”
Yes. Actual change.	No	“I also drilled the words.”
No. Self-knowledge.	Yes	“I have experience and confidence in these learning techniques.”
No. OK.	No	“I did not change a thing because I think it was OK.”
No. OK, lack of time.	No	At the end, I had too little time and memorized the words via reminders.”

The re-analysis of the responses of Group C, this group had three effective planning tasks and one problem-solving task involving actual situation and flexibility across time, showed six ways of describing a change of plan (see Table 4): selecting either yes or no with regard to making changes to the plan and describing (a) in a logical manner why the change was appropriate; (b) the considering of making a change(s), but not actually going through with it; (c) the employing of different learning techniques than initially planned, but not focusing on the logic or why it was done in this way; (d) the knowing of, based on learning experiences, that these learning techniques are sufficient for short-term learning and oneself; (e) saying that all went well and leave it at that; and (f) saying that all went well except for a lack of time (i.e., it could not be done in the ten minutes). It was concluded that when tasks can build forth on to one another, it could provide for insights about the kind of changes in behavioral decision-making. However, the responses did not inform about the duration of time that is required in-between the tasks and the way of interpreting the context, the intensity of observing the situation (i.e., timescales), nor about feedback loops.

Regarding the concepts of the theoretical framework of Figure 2, the responses of Group C showed that (a) some students ($n = 12$) mentioned their preferred learning techniques (i.e., typical behavior), (b) some students ($n = 4$) reckoned with learning progress, but only during learning and not during planning, some due to lack of time ($n = 2$) and unsatisfactory learning technique ($n = 2$), (c) one students ($n = 1$) described active pattern seeking as an essential learning technique, and (d) none of the students mentioned feelings of competence/uncertainty regarding task performance, circumstances, and reoccurring thoughts and feelings. Then again, the questions had not inquired about these subjects explicitly. Additionally, none of the found concepts of the theoretical framework of Figure 2 in the responses of Group C were in agreement with a correct solution of the problem.

It was concluded that, due to the high level of attention required to learn and solve the tasks, integrated open-ended questions should employ some kind of support to help the participants in considering these concepts.

Discussion

Overall, the *process* of behavioral decision-making was not assessed because information about timescales and feedback loops did not become available. The responses provided information about situational features in general and behavioral-decision results, but it did not give precise information about the process or the kind of changes that can occur based on the interpretation of certain situational features, the context, and someone's circumstances. Although the complex tasks did challenge the participants to engage in alternative learning and problem-solving behavior, the non-routine nature of the tasks complicated the execution of the tasks.

Study 2: A Case Study

This study reports on one adult student as participant and collaborator to bring about the *process* of behavioral decision-making for learning and problem solving via mixed method research integrated closed- and open-ended questions. Closed-ended questions were needed because the data collection of timescales requires quantitative information.

Method

Participants. The participant (man, age ≥ 50 years) has been a Duolingo student for the past four years (i.e., foreign French language, highest “diamante league” level, and has a “streak credit” for doing a minimum of one lesson every day). Having an educational level and professional career at academic level, this participant was selected for this study because (a) not a full-time student trained in doing tests, no social-behavioral scientific background, and not trained in self-reflective learning (i.e., a government laid down educational reform since 1993), hence, no experiences and knowledge in what is expected (i.e., socially desirable responses) in describing one’s mental process of learning and problem-solving, (b) likely to be more prone to circumstances than students due to adult-life responsibilities, (c) familiar with school tasks due to learning a foreign language every day of one’s own accord, hence, can communicate about learning and problem solving, and (d) being available for this study as a participant and collaborator.

Procedure. There were four sessions, each session consisting of two parts: (a) doing the task and responding to the integrated closed- and open-ended questions as a participant (i.e., according to the introduction) and (b) responding to the structured interview as a study collaborator (i.e., thinking about how to capture the process behind doing the task via the integrated closed- and open-ended questions). The introduction consisted of a text that (a) explained the purpose of obtaining insights about persons’ thoughts, feelings, and deciding during task execution, (b) assured individuality (i.e., there are no correct answers, just personal ones) and anonymity, and (c) explained how to fill in the integrated closed and open-ended questions (i.e., no training, only explanations of terms). The researcher was allowed to respond to questions, but without elaborating (i.e., being restricted to employ the same or similar terminology). Next, the first task session took place, and each consecutive day, another task session was executed. During the first task session, the participant could choose a learning task (i.e., words or numbers), for the second task session, the other learning task was presented. The third and fourth task sessions consisted of the problem-solving tasks. Only for the first two data-collection sessions, the researcher set the time to learn, but problem solving and filling in questions had no time limit.

Instruments. There were two complex learning and two complex problem-solving tasks. The complexity of the tasks consisted of their difficulty level and the amount of information provided without it having any interconnection or logic. The first learning tasks had 21 difficult words (i.e., regarding spelling and being rare), the second learning tasks had 12 series of eight random numbers. The problem-solving task related to the learning of words was “Use ten of the memorized words of the learning task and make a poem,” and the problem-solving task related to learning numbers was “Use four series of memorized numbers and solve each series by making calculations that include each number, without multiplying and dividing by zero, in such a manner that the final result is zero (e.g., $6399 = [6 \times 3 = 18]$, $[9 + 9 = 18]$, $[18 - 18 = 0]$).

The development of the integrated closed and open-ended questions followed four guidelines: (a) collect multiple sources of evidence; (b) rule out alternative explanations; (c) prompts cannot steer in certain directions; and (d) include the concepts of Figure 1 and Figure 2. Hence, the questions inquired about the time of each behavioral decision-making moment to understand the length of feedback loop. The intensity of the moment was assessed via the urgency of one’s thoughts and feelings, which had to

be rated on a three-point scale: (a) little (i.e., maybe I should try something else); (b) neutral (i.e., I need to do something else); and (c) strong (i.e., I urgently need to do something else). Inquiries were also made regarding the following concepts of Figure 2 (i.e., as presented on the question form): changes in (a) concentration (i.e., more or less directing of attention); (b) method (i.e., how to tackle the task); (c) knowledge (i.e., memorized information to support the task); (d) wandering thoughts (i.e., thinking about other stuff); (e) uncertainty (i.e., being unsure about something); and (f) other.

The structured interview had an open-ended character, in that the participant could answer in his own words, but the interview questions were determined in advance based on the findings and results of a previous data-collection session (see Results). Specifically, the participant was now in the role of study collaborator and was asked expressly how the questions could be improved to assess the process of behavioral decision-making.

Data Analysis. Content analysis was employed by transcribing and coding the responses to identify categories or themes. The thus identified categories were checked with the meaning of the concepts of the theoretical framework of Figure 2.

Results

Theoretical concepts of Figure 2. The amount of theoretical concepts circled per response was on overall $M = 1.20$ ($SD = 0.40$). Content analysis of the responses showed variation in meaning regarding the circled concepts. For example, the concept of concentration could refer to background noise as a hinder and worrying about one's competence (see Table 5). The concepts did elicit comprehensive descriptions suitable for content analysis and provided for descriptions of one's personal characteristics.

Table 5

Theoretical Concepts (Figure 2) Circled and Response Description

Concept	Meaning	Characteristic/I am ...
Concentration	Background noise hinder; Worry about competence; Difficulty level of task; Cut of myself from noise; Being in a flow.	I find drilling annoying; Memorizing is always stressful for me.
Method	Clustering; Finding a method; How to begin.	I always try to connect info; I enjoy a study method that gives structure.
Knowledge	Memorization problems.	
Wandering thoughts	Realizing time pressure	Difficult information always leads to wandering thoughts.
Unsure	Unfamiliarity of task; Difficulty level of task; Can I memorize it?	
Other	Memorizing via writing; Slow progress; Nice task, feels good.	

Question Format. Based on the interview information, the question form was improved and then tested in the following data-collection session (see Table 6). Hence, the invitation to respond in one's own words as comprehensively as possible became "Please, clarify comprehensively what you think/feel, why you now consider the task execution, and do you consider making changes," to point out the concept of feedback loop. The title for each question first was "Personal timeline – How I respond today," as a reminder of the task situation today, however, it led to an untidy question format (i.e., a lot of reading required while the question form already interferes with the task execution) and it did not elicit information about behavioral decision-making in the situation compared to one's usual way of behaving. Hence, it was decided to add a final open-ended question to collect information about the context in relation to circumstances, which turned out to be an improvement. The concept of urgency, to assess the felt pressure of considering task execution, was a difficult concept and did require a further explaining in the question form. Both the to-be-circled concepts and urgency ratings are explained in the introduction text that is placed in advance of the questions. The participant mentioned that responding to the questions was distracting to the learning and problem solving of the tasks.

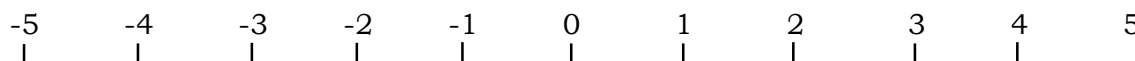
Table 6

Properties of the Developed Integrated Closed- and Open-Ended Question Form

Timescales and feedback loop question	
<p><i>Time</i> 10:00</p> <p><i>Please circle</i> <i>urgency for</i> <i>considering:</i></p> <p>Hardly Necessary Strong</p> <p>10:25</p>	<p><i>Please circle: Concentration – Method – Knowledge – Wandering thoughts – Uncertainty – Other</i></p> <p><i>Please, clarify what you are thinking and feeling, why it is now that you consider yourself executing the task, and will you make changes:</i></p> <p><i>Time of ending.</i></p>

Final question

Today I executed the task differently (negative or positive) than I usually do, please circle:



When I had to do this task during homework, then ...

Note. The blue colored time is filled in by the participant.

Timescales. The noticing of timescales per task session (see Table 7) showed that the overall considering of one's behavioral decision-making took place in relative short periods of time ($M = 3.76$ and $SD = 1.94$ minutes) with hardly to neutral urgency ($M = 1.57$; $SD = 0.76$). The overall meaning of the responses for the fewest time periods and highest mean minutes was being stuck in doing the task, and the highest time periods and lowest mean minutes was for experiencing flow in doing the task.

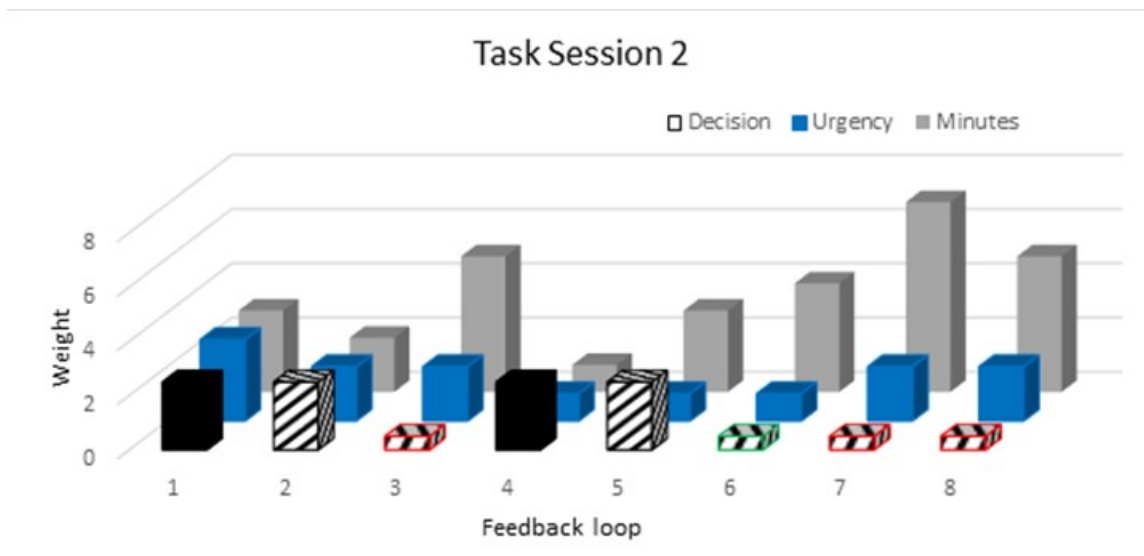
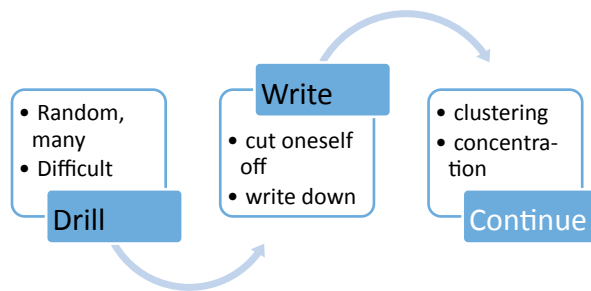
Table 7*Contrast of Timescales Per Data-Collection Session or Task*

Variable	n	Session 1		N	Session 2	
		M	SD		M	SD
Learning	6			8		
Minute		4.00	1.79		3.33	1.50
Urgency		1.17	0.37		1.67	0.67
		Session 3			Session 4	
Solving	5	Stuck		10	Flow	
Minute		5.20	2.86		3.33	1.62
Urgency		2.40	0.80		1.30	0.64

Note. n = amount of timescales provided. Minute = clock-time in minutes. Urgency = in 3-point rating scale (1 = hardly, 2 = necessary, and 3 = strong).

The Feedback Loop. Taken together, the multiple sources of data now raises the question of how can it inform about the process of behavioral decision-making via feedback loops. The data captured the process in a twofold manner via (a) the process diagram supplemented with content analysis and personal characteristics (see Table 5) and (b) the connection between timescales and feedback loops by visualizing (i.e., process) and quantizing (i.e., attaching numbers) the analyzed responses (see Figure 3). Regarding the process diagram, it is a visualized overview that makes clear what was going on or what happened in the situation according to the participant. Regarding the quantizing of the connection between timescales and feedback loops, first, there is the amount of filled in questions as considering moments (see Appendix A). This was presented in the graph and table via separate blocks to indicate that these feedback loops were noticed by the participant. That is, some mental processes are likely to get lost in becoming aware of one's considerations about the situation. Second, there is the kind of consideration. Theoretically, decision and pre-decision were assumed, but the data showed also the continuing of (pre-) decisions. This was presented in the graph via shape, color, and effects. Third, there is the meaning or the kind of information that is considered. This was presented in the graph via the height of the blocks. Theoretically, habitual and new alternative behaviors were assumed, however, the data showed that in a learning and problem-solving situation, there were three categories: (a) no study (e.g., being unsure, worrying, and wandering thoughts; (b) basic study (e.g., concentrating, summarizing, clustering, and rewriting); and (c) higher-level study (e.g., understanding, critical thinking, searching for an alternative study method).

Figure 3 shows the connections between the data of the integrated closed- and open-ended questions while being fair to the distinction between quantitative and qualitative data to capture the participant's characteristics in relation to the context and the feedback loops. Figure 3 implies that Task Session 2 for this participant resulted in the process of dealing with a difficult task and resorting immediately to basic study methods and continuing to do so even though it did not work fine. However, Appendix B shows how the participant dealt with the other three tasks during the data-collection sessions by employing different kinds of study methods. Appendix B also shows that it was possible to apply the visualizing and quantizing of the timescales and feedback loops to the data of all four tasks.



Feedback loop	1	2	3	4	5	6	7	8
Minutes	3	2	5	1	3	4	7	5
Urgency	3	2	2	1	1	1	2	2
Decision	2.5	2.5	0.5	2.5	2.5	0.5	0.5	0.5

Figure 3. Display of the connection and meaning of timescales and feedback loops.

To see if the results of the four tasks can be combined into an overview of this individual person in the complex study situation, the main deviation features in the connection between timescales and feedback loops were (a) dealing with unhandleable versus handleable task situations (i.e., Task Session 3 compared to Task Sessions 1, 2, and 4), (b) the feedback loop duration, (c) the meaning of the decision (i.e., which kind of study method), and (d) the experienced level of urgency of the feedback loops (see Figure 4). Figure 4 shows that the participant decided on a study method only if the task situation has become handleable because if not all of the required learned

information could be remembered (i.e., Task Session 3, color red) then the participant would not decide on a study method. Also, all tasks led to only employing basic study methods, which might have been caused by the tasks themselves. Figure 4 also shows that the duration of the feedback loops is longer in the unhandleable task situation than in the handleable situation. Finally, Figure 4 shows that in the handleable task situation, it takes two feedback loops (of $M = 3.45$) for the participant to decide on a different study method if the present study method is working insufficiently (i.e., the black dots on the green line).

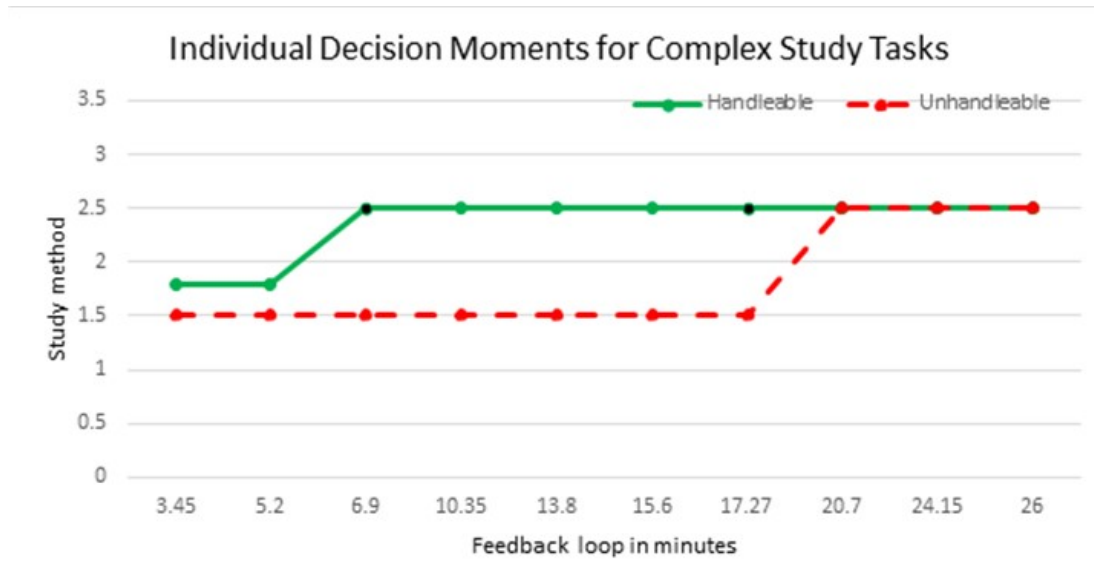


Figure 4. Display of the participant variation in feedback loop duration in the complex study situation. Handleable = can manage to solve the task (i.e., task sessions 1, 2, and 4). Unhandleable = postpones to solve the task because of first wanting to remember the information that is necessary to solve the task (Task Session 3). Feedback loop duration for Handleable $M = 3.45$ ($SD = 1.30$) minutes and for Unhandleable $M = 5.20$ ($SD = 2.86$) minutes. The kind of study method was 1.5 = no study method, 2.5 = basic study method, and 3.5 = high-level study method. The color green has $M = 0.40$ and the color red has $M = 0.41$ regarding urgency, which can be neglected.

Summary and Concluding Discussion

This preliminary study gave information about how to measure the behavioral decision-making process via mixed method research integrated closed- and open-ended questions that inquired about timescales and feedback loops. Although there is the limitation that responding to these questions interferes with executing the learning and problem solving tasks, the obtained data could inform about the person in the situation. This does raise the question of whether the assessed feedback loops should be called noticeable feedback loops because it is not likely that all mental processing of the situation is noticeable to the participant. Future research can examine if the afterwards replenishing of the responses is an option to obtain better-clarified information. Another limitation was the case study of just one participant. This means

that the content analysis of the responses may provide for different categories, which can have consequences for the quantizing of the feedback loop data. It also means that questions about the practical suitability, best data-analytical technique, and validity and reliability require future research studies. A final limitation is that circumstances, which are expected to influence the interpretation of a challenging situation where the maintaining of behavioral balance is required, were not assessed completely satisfactory in terms of clearly having an impact on the findings and results because more students are needed for comparison.

What is different in this study is that the data analysis and presentations of the findings and results showed mixed method research integrated data while being fair to the different nature of qualitative and quantitative data. And did it work, in terms of measuring the process of behavioral decision-making? Although the findings and results of the one-person case study were made visible and interpretable meaningfully, future research studies are required to answer this question.

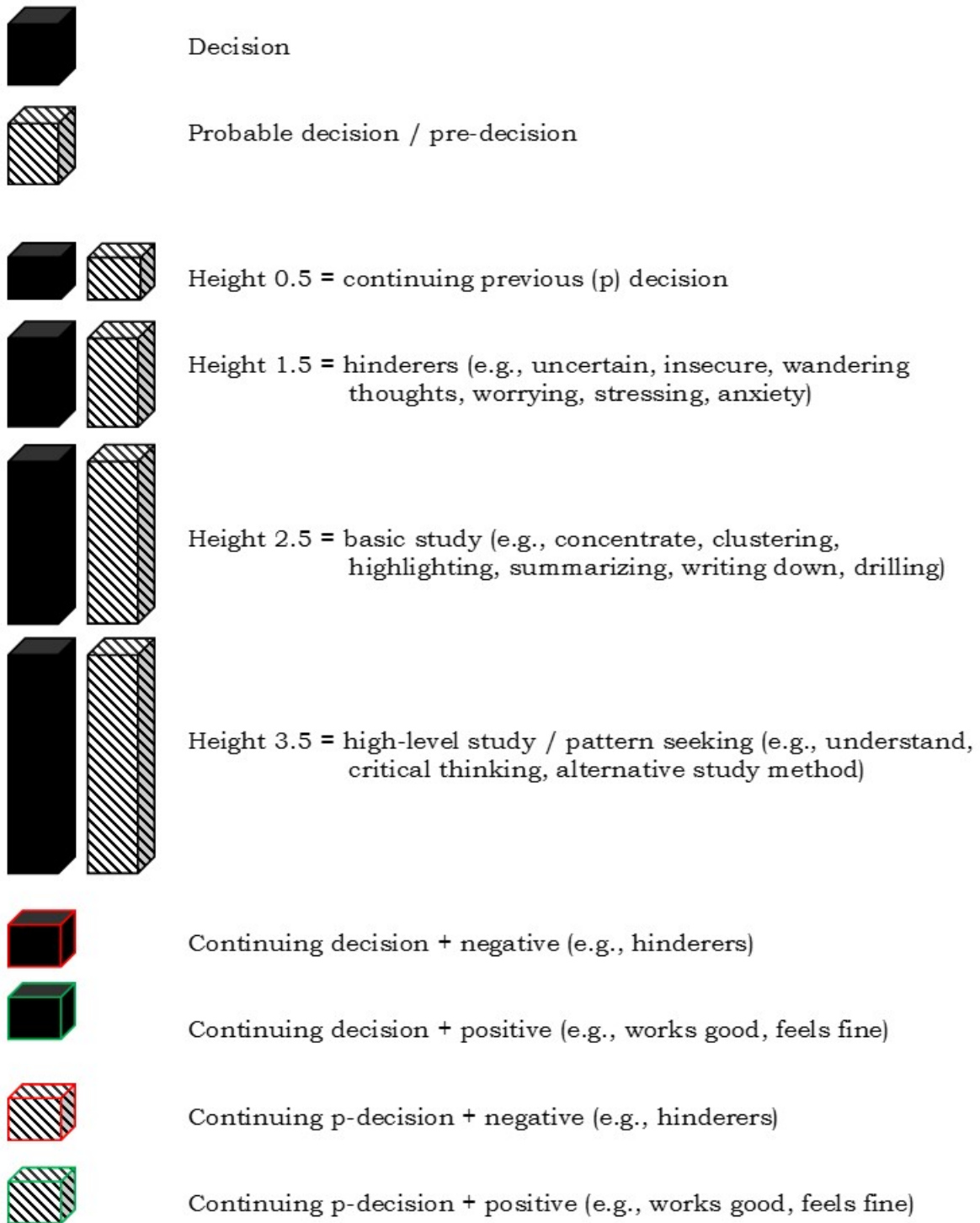
Overall, when phenomena and processes in the actual world are dynamic, such as the process of behavioral decision-making, then it can be difficult to understand them because they may not be easily simplified with regard to obtaining and analyzing data. That is, phenomena and processes that are dynamic may be understood best by studying them holistically, however, holistic research comes with the drawback of having to deal with multiple interconnecting variables, of which some are latent and others unknown (i.e., they have to emerge, which requires measurements that help them to come to light), and varying and unknown change patterns across time. Therefore, when the function of dynamic processes could become better understood, then this may lead to predicting their progression across time in terms of having certain expectation patterns because of knowing when and why they can exist.

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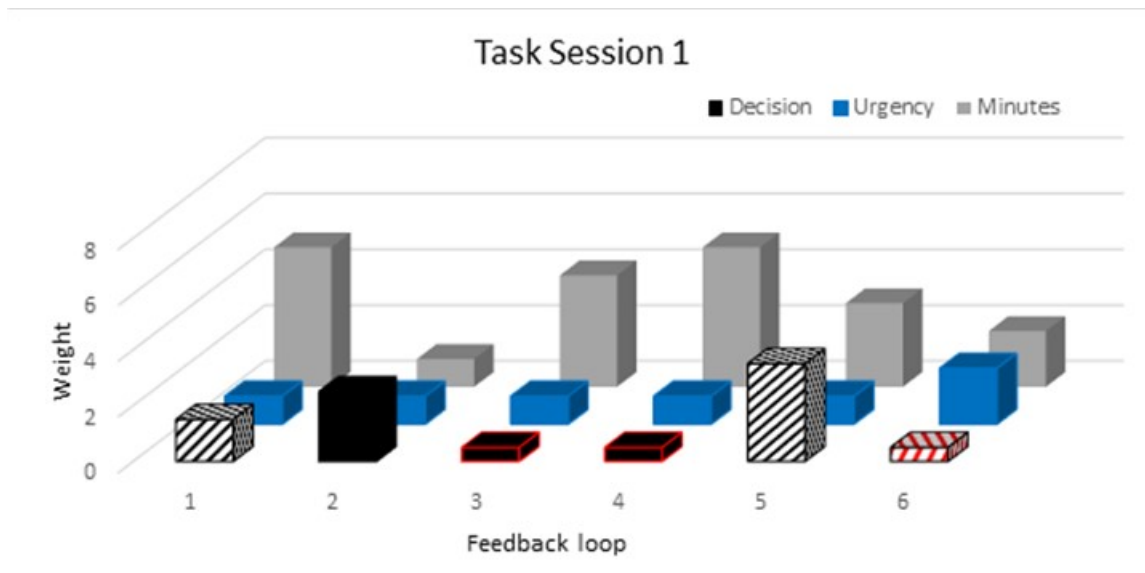
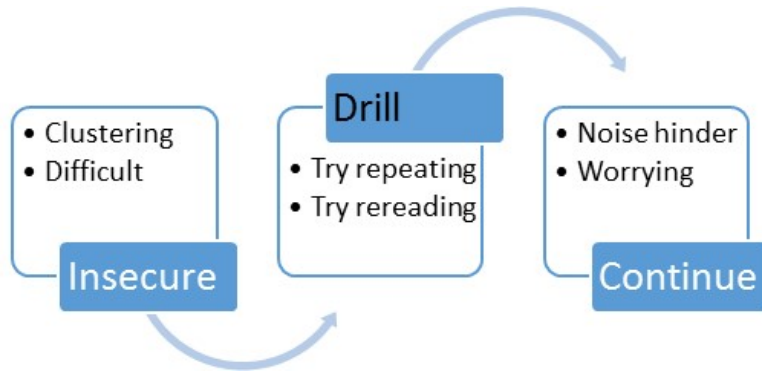
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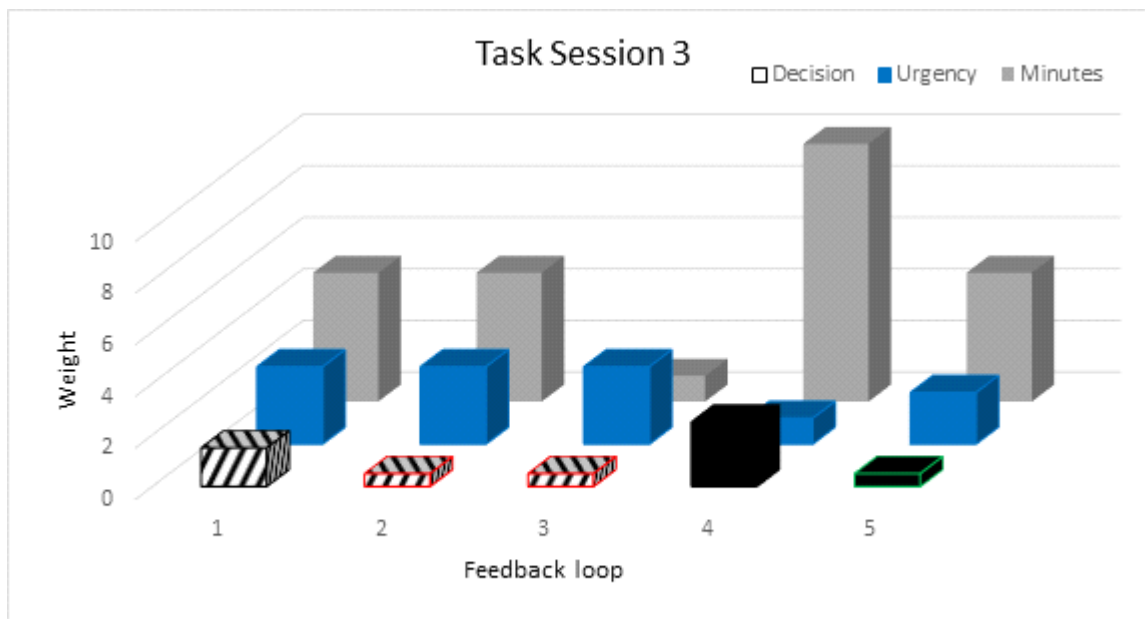
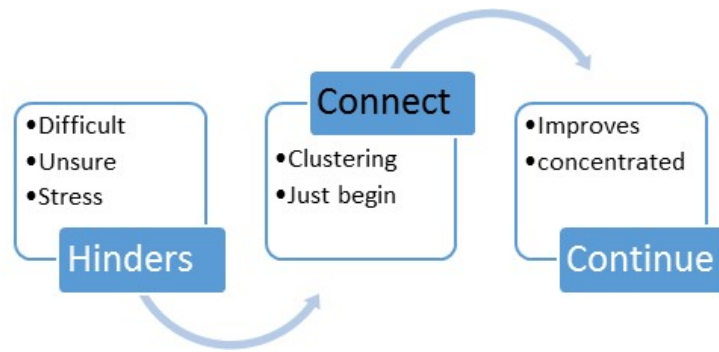
Appendix A Quantitizing the Feedback Loop



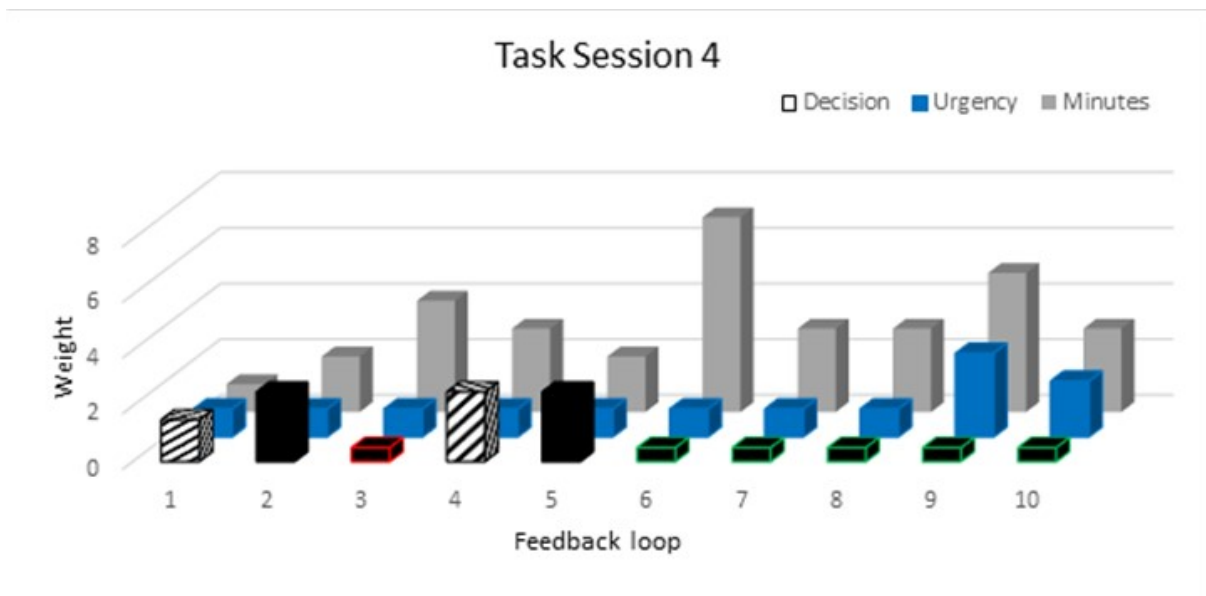
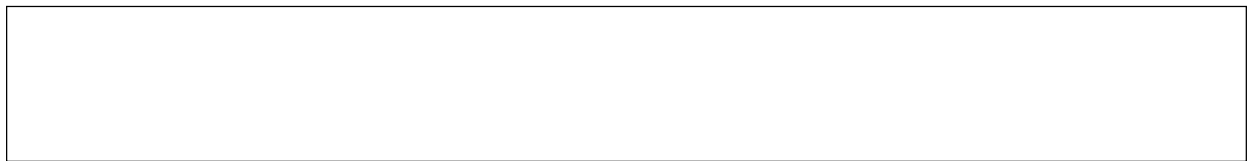
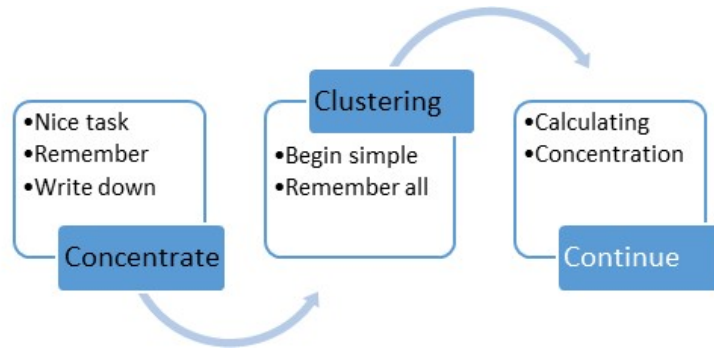
Appendix B Display of the Connection between Timescales and Feedback Loop per Task Session



Feedback Loop	1	2	3	4	5	6
Minutes	5	1	4	5	3	2
Urgency	1	1	1	1	1	2
Decision	1.5	2.5	0.5	0.5	3.5	0.5



Feedback Loop	1	2	3	4	5
Minutes	5	5	1	10	5
Urgency	3	3	3	1	2
Decision	1.5	0.5	0.5	2.5	0.5



Feedback loop	1	2	3	4	5	6	7	8	9	10
Minutes	1	2	4	3	2	7	3	3	5	3
Urgency	1	1	1	1	1	1	1	1	3	2
Decision	1.5	2.5	0.5	2.5	2.5	0.5	0.5	0.5	0.5	0.5

Author Note

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Conflict of Interests

The author declares that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

Citation

Van Velzen, J. H. (2025). Measuring the process of behavioral decision-making: A preliminary study on quantizing the feedback loop. *RRREaT – Data-Analytical Techniques*, 1:02. Retrieved from <https://sigmetack.com>.

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