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Effects of performance feedback valence on perceptions of invested mental effort

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ABSTRACT

We investigated whether the valence of performance feedback provided after a task, would affect participants' perceptions of how much mental effort they invested in that same task. In three experiments, we presented participants with problem-solving tasks and manipulated the presence and valence of feedback between conditions (no, positive, or negative feedback valence), prior to asking them to rate how much mental effort they invested in solving that problem. Across the three experiments—with different problem-solving tasks and participant populations—we found that subjective ratings of effort investment were significantly higher after negative than after positive feedback; ratings given without feedback fell in between. These findings show that feedback valence alters perceived effort investment (possibly via task perceptions or affect), which can be problematic when effort is measured as an indicator of cognitive load. Therefore, it seems advisable to measure mental effort directly after each task, before giving feedback on performance.

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1. Introduction

Providing learners with feedback has proven effective for enhancing performance (Hattie & Timperley, 2007), both in classrooms (e.g., Bangert-Drowns, Kulik, Kulik, & Morgan, 1991), and in computer-based learning environments (e.g., Van der Kleij, Feskens, & Eggen, 2015). This feedback will have a certain valence for learners: when the feedback tells them their performance was incorrect, or lower than they expected, it has negative valence; when it tells them their performance was correct, or higher than they expected, the feedback has positive valence. The question addressed in the present study, is whether the valence of performance feedback on a task, has consequences for participants' perceptions of how much mental effort they invested in that task.

This question is of both theoretical and practical relevance, because subjective ratings of how much mental effort students'

perceived to have invested in a task, are widely used in educational research and in (adaptive or self-regulated) computer-based learning environments as an indicator of the cognitive load that learners experienced (Paas, 1992; Paas, Van Merriënboer, & Adam, 1994; for reviews, see; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Van Gog & Paas, 2008). Theoretically, we still know very little about the “cues” that learners use when they are asked to rate how much effort they invested in a task. That is, learners' perceptions of effort investment presumably rely on multiple aspects of their experiences during task performance (i.e., cues, such as how difficult, fluent, or speedy the performance process was). Investigating whether there are external influences (such as feedback valence) on effort perceptions would be a first step towards attaining insight into which cues are probably being used. Practically, it is imperative that effort measures reliably reflect experienced cognitive load, which is no longer the case when learners' effort perceptions would be affected post-hoc by external influences (such as feedback valence). Thus, investigating whether such external influences occur, can help inform researchers and practitioners on when to best measure learners' perceptions of invested mental effort.

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1.1. Use of mental effort ratings in educational research and learning environments

According to Cognitive Load Theory (Sweller, Ayres, & Kalyuga, 2011), cognitive load originates from an interaction of task characteristics (e.g., the more complex the task, the higher the load it imposes) and learner characteristics (e.g., the higher a learner's knowledge, the lower the load imposed by the task). Cognitive load can be assessed in terms of processing demands, using objective measures such as dual-tasks (Brünken, Plass, & Leutner, 2003), or physiological measures (Paas, Tuovinen, Tabbers, & Gerven, 2003), or in terms of experienced cognitive load, by asking learners to rate how much effort they invested in a task. Mental effort is defined as “the aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task; thus, it can be considered to reflect the actual cognitive load” (Paas et al., 2003, p. 64). Both types of measures have their strengths and weaknesses. Objective measures, are less easy to administer than subjective ratings, but have the benefit of providing moment-to-moment information regarding (fluctuations in) processing demands during task performance. Subjective measures, in contrast, are easy to administer and also seem sensitive to variations in cognitive load (which, as mentioned above, originates from an interaction between task and learner characteristics): subjective perceptions of effort investment have been shown to increase (or decrease) with increases (decreases) in task complexity (e.g., Paas et al., 1994; Schmeck, Opfermann, Van Gog, Paas, & Leutner, 2015), to be lower for learners with higher prior knowledge compared to learners with lower prior knowledge working on the same task (e.g., Nieveelstein, Van Gog, Van Dijk, & Boshuizen, 2013), and to decrease from pretest to posttest as a consequence of knowledge acquired during a study phase (e.g., Hoogerheide, Loyens, & Van Gog, 2014). Which method is most appropriate depends on the research question being addressed.

Our present study is concerned with subjective perceptions of invested mental effort. Since it was first published, the 9-point mental effort rating scale¹ developed by Paas (1992) has become widely used in research on learning and instruction, as an indicator of learners' experienced cognitive load (for a review, see Van Gog & Paas, 2008). In combination with performance measures, subjective perceptions of how much mental effort was invested in a task are useful for obtaining information about the efficiency of instruction (Hoffman & Schraw, 2010; Paas & Van Merriënboer, 1993; Van Gog & Paas, 2008), and for guiding the selection of learning tasks in adaptive (e.g., Salden, Paas, Broers, & Van Merriënboer, 2004) or self-regulated (e.g., Kostons, Van Gog, & Paas, 2012) learning environments. For instance, Kostons et al. (2012) trained students how to select a next task based on a combination of their (self-assessed) performance and perceptions of invested mental effort. After a self-regulated learning phase, participants who had been trained in task selection showed higher knowledge gains than students who had not received training. This study exemplifies the usefulness of effort measures not only for educational research but also for educational practice (i.e., in improving self-regulated learning).

In order to effectively use effort measures in educational research or educational practice, however, it is imperative that learners' perceptions of invested mental effort reliably reflect experienced cognitive load. It is therefore important to investigate

whether there are external factors (other than learners' own experiences with the task) that might affect learners' perceptions of how much effort they invested in a task, but such research is still scarce. Some recent studies have been conducted on when to best administer the effort rating scale, in which it was found that a single, overall rating of effort invested in a series of tasks, was systematically higher than the average of task-specific ratings given immediately after each task (Schmeck et al., 2015; Van Gog, Kirschner, Kester, & Paas, 2012).

These findings suggest that it is preferable to measure perceptions of invested effort directly after each task; however, it is still unclear what causes this discrepancy between overall and task-specific ratings. Which brings us to the theoretical relevance of investigating whether and how external factors affect learners' perceptions of how much effort they invested in a task: as mentioned earlier, we still know very little about what cues learners use when they are asked to rate how much effort they invested in a task. In analogy to metacognitive judgments, it is likely that learners use certain cues resulting from their experience with the task as a basis for their effort ratings. Knowing whether and which external influences affect learners' effort perceptions would constitute a first step towards attaining insight into what cues they are probably using. We start out here, by investigating whether and how the valence of performance feedback affects perceptions of invested effort.

1.2. Cue utilization, feedback, and mental effort ratings

Research on metacognitive monitoring judgments (e.g., judgments of learning; JOLs), has come a long way in past decades in uncovering which sources of information (i.e., cues), learners use when predicting their future memory performance (Koriat, 1997, 2015). In the cue utilization view of JOLs, Koriat distinguishes three types of cues: intrinsic, extrinsic, and mnemonic cues (Koriat, 1997). Intrinsic cues concern inherent attributes of the study material associated with the ease or difficulty of learning. For instance, learners may judge how well they will remember a certain word-pair based on the relatedness between the words, as higher relatedness is generally associated with better memory (e.g., Begg, Duft, Lalonde, Melnick, & Sanvito, 1989). Extrinsic cues are related to how the material is presented (e.g., the number of repetitions of an item, available study time) or what strategy the learner applies when studying (e.g., level of processing, imagery). Intrinsic and extrinsic cues can affect JOLs directly, but also indirectly, by affecting the third type of cue, mnemonic cues (Koriat, 1997). Mnemonic cues can be described as internal signals from subjective experience that might indicate that information has been learned and will be remembered on a future occasion, such as fluency during encoding or retrieval (Koriat & Ma'ayan, 2005). As a learner engages with a task, the judgment shifts from being information-based (i.e., relying on intrinsic and extrinsic cues) to more experience-based (i.e., relying on mnemonic cues; Koriat & Ma'ayan, 2005).

Indicating how much effort you invested in a task that you just completed, is, of course, very different from predicting your future memory test performance by means of a JOL (indeed, effort invested in learning can in itself serve as a cue for a JOL: Koriat, Ackerman, Lockl, & Schneider, 2009; Koriat, Nussinson, & Ackerman, 2014; see also Baars, Vink, Van Gog, De Bruin, & Paas, 2014, who found a negative correlation between learners' perceptions of invested effort and their JOLs). Nevertheless, rating how much mental effort you invested in a task also constitutes a subjective, introspective judgment, that learners likely make using experience-based cues (such as their perceptions of how difficult, fluent, or speedy the task performance process was). And some of

¹ “How much mental effort did you invest in solving this problem?” with answer options ranging from (1) very very low effort, to (9) very, very high effort. Depending on the task, the question could also be phrased as “... in studying this text/animation/worked example”.

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