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Mapping introspection's blind spot: Reconstruction of dual-task phenomenology using quantified introspection

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ABSTRACT

Psychologists often dismiss introspection as an inappropriate measure, yet subjects readily volunteer detailed descriptions of the time and effort that they spent on a task. Are such reports really so inaccurate? We asked subjects to perform a psychological refractory period experiment followed by extensive quantified introspection. On each trial, just after their objective responses, subjects provided no less than four subjective estimates of the timing of sensory, decision and response events. Based on these subjective variables, we reconstructed the phenomenology of an average trial and compared it to objective times and to predictions derived from the central interference model. Introspections of decision time were highly correlated with objective measures, but there was one point of drastic distortion: subjects were largely unaware that the second target was waiting while the first task was being completed, the psychological refractory period effect. Thus, conscious perception is systematically delayed and distorted while central processing resources are monopolized by another task.

1. Introduction

Performance and response time are common tools in cognitive sciences, but the subject's conscious experience has been largely left aside. Indeed, first-person introspection is usually considered as a suspicious procedure that cannot provide much useful information about internal cognitive processes and must be replaced by third-person objective measurement. For instance, experiments in social psychology indicate that participants can be completely unaware of the true causes of their choice behaviour or of the cognitive processes leading them to the solution of a problem (Nisbett & Wilson, 1977). Ericcson and Simon (1980) stressed that asking subjects for a formal verbal reports of their thought processes could only be informative about a specific subset of non-automatic cognitive processes, and drew attention to the fact that the very act of reporting could alter ongoing processing. Even so, in the history of psychology, introspection never really left the scene as it remained in use both as a debriefing tool and as an essential source of data in psychophysical experiments. With the recent resurgence of interest for consciousness and its determinants, it becomes essential to reconsider whether introspection really is inaccurate and unusable – or whether it is a valid object of cognitive study, like any other, with its valid range of operation and its limits.

We recently introduced a new method aimed at quantifying subjects' conscious introspection of a cognitive task (Corallo, Sackur, Dehaene, & Sigman, 2008). The general concept of quantified introspection involves collecting from subjects, on a trial-by-trial basis, precise quantitative

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data about a subjective variable such as stimulus visibility, location, duration, etc. In particular, the method of introspective response time involves engaging participants in a standard response time task, then collecting, on each trial, a quantitative subjective estimate of the duration of their decision. On each trial, we therefore obtain an objective and a subjective response time, which can be correlated and contrasted. The method implies that subjects monitor their own cognitive operations, register this monitoring in some form of memory, and finally retrieve the relevant information at the end of the main trial in order to perform the requested time estimation. This meta-cognitive measure provides a new opportunity to explore the links between cognitive processes and conscious reports. In our previous work (Corallo et al., 2008), we only studied introspective RT in one or two tasks. In the present study, we show that this method can be dramatically enhanced by asking multiple quantitative questions on a single trial. Our new results indicate that participants can answer no less than four quantitative introspective questions about the preceding RT trial, and that these combined measures can be used to reconstruct a detailed picture of its phenomenology.

Subjective reports have already been used in many magnitude estimation studies. For example, people can estimate the visibility of a target stimulus by using a continuous scale. The visibility rating is strongly correlated with the objective detection performance and is influenced by the same experimental manipulations (Del Cul, Baillet, & Dehaene, 2007; Sergent, Baillet, & Dehaene, 2005; Sergent & Dehaene, 2004). In our recent study, we parametrically examined introspective response times (iRT) and objective response times (RT) in a number comparison task (Corallo et al., 2008). The results showed that introspective and objective RTs were influenced by the same experimental manipulations (numerical distance and notation type) and were strongly correlated. This shows that iRTs are a reliable measure, closely related to standard RTs.

A dual-task paradigm, however, revealed a clear limit of introspective RT. When people have to respond as fast as possible to two successive stimuli, the response time to the second target T2 (RT2) increases as the stimulus onset asynchrony (SOA) decreases, while response time to the first target T1 (RT1) remains unaffected – the so called psychological refractory period (PRP) effect. The PRP shows that part of T1 processing is strictly serial thereby delaying T2 processing (Pashler, 1994; Telford, 1931). The central interference model proposes that only one of three major cognitive stages is delayed in T2 processing (Pashler, 1994; Sigman & Dehaene, 2005, 2006, 2008; Sigman, Jobert, Lebihan, & Dehaene, 2007). Perceptual and motor operations can be processed in parallel but a central decision stage is strictly serial and constitutes the main processing bottleneck (see Fig. 3A for a graphic depiction). Hence, according to this model, other central on-line cognitive operations such as decision making or conscious access might suffer from this bottleneck.

According to dual-stage models of conscious access (Chun & Potter, 1995; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Dehaene, Sergent, & Changeux, 2003; Del Cul et al., 2007; Sergent et al., 2005), conscious perception of T2 relies on the same sort of central processing that is required for the T1 decision, and thus should be delayed until the T2 information is able to access the central processing stage. During the PRP, subjects would therefore suffer from a misperception of external sensory events – their perception would be delayed until T1 processing is completed. In the second experiment of Corallo et al. (2008), we provided a first partial test of this hypothesis. During the PRP interference, a clear dissociation was observed between RTs and iRTs: RTs depended strongly on the SOA between the two stimuli, reflecting the fact that T2 processing had to wait for T1 completion, but iRTs were unaffected by this SOA, compatible with the idea that subjects only had access to T2 processing once they were free from the T1 task.

However, the introspective questions used in Corallo's study were not sufficient to provide a complete test of our model. In particular, they did not explore the reasons behind the subject's inappropriate reports. Our hypothesis is that T2 itself cannot be perceived until the central stage is freed from T1 processing. An alternative possibility exists, however. Although we insisted that subjects should report the full time elapsed between the objective appearance of T2 and their corresponding response, subjects could have misunderstood these instructions and merely reported the duration of their central decision time only. According to the central interference model, this central duration should be unaffected by SOA, precisely as the subjects reported.

The goal of the present research is to attempt to explain *why* introspection is blind to dual-task interference – we propose and put to a test an actual theory of what introspection can and cannot measure. Our experiment directly probes whether a genuine illusory misperception of time exists during dual-task processing, aiming to show that during the interference period, the conscious perception of the second target is delayed until processing of T1 is completed. To achieve these aims, we investigate the subject's introspections of PRP trials in much greater detail than earlier, asking them no less than four quantitative introspective report which, together, provide a complete picture of how subjective time evolved during a dual task.

The primary task was to respond as quickly as possible to an auditory tone and then to a visual stimulus. In addition to the objective response times, we recorded subject's responses to four subjective questions (see Fig. 1C) asking them to evaluate their response times to task 1 and to task 2 (iRT1 and iRT2), the perceived stimulus onset asynchrony (iSOA), and finally the slack or free time (iSF). The latter variable evaluates the availability of the central stage in between the two tasks. At short T1–T2 SOAs, when T2 has to wait while T1 is being processed, the T2 waiting time is called "slack time". Conversely, we call "free time" the gap that exists, at longer T1–T2 SOAs, between the moment when task 1 is completed, and the moment when task 2 is started.

Our experiment had two goals: (1) to reconstruct the phenomenology of an "average" PRP trial based on introspective data; (2) to test predictions arising from the hypothesis that conscious perception of the second target requires central-stage processing and is therefore delayed during the PRP. Our refined introspective variables allow