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Further evidence for functional differences between guessing versus choosing an upcoming task

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ABSTRACT

We replicated and extended previous evidence regarding functional differences between guessing versus choosing an upcoming task. Participants switched among four tasks and were asked to predict the upcoming task on each trial. These predictions were instructed to participants as either 'guessing' or 'choosing'. Furthermore, we varied the proportion of trials in which the presented task conformed to participants' predictions on three levels. Whereas with choosing instructions unexpectedness affected task switches and repetitions similarly, leaving switch costs unchanged, with guessing instructions switch costs were reduced, that is, task switches were affected less than repetitions. This interaction was unaffected by the proportion of expected tasks. We propose that with choosing, the impact of a mismatch between chosen and presented tasks is reduced by explicit knowledge regarding the proportion of denied choices. With guessing, task unexpectedness mainly increases task difficulty, which is compensated by an increase of cognitive control that reduces switch costs.

1. Introduction

Predictions drive cognition. On the one hand, predictions induce preparatory adjustments that facilitate the processing of expected sensory input and prime actions according to this. On the other hand, deviations from expectations induce compensatory adjustments in order to minimize the consequences of these deviations. It has even been argued that the minimization of prediction errors is the primary information-processing function of the brain (the 'predictive coding theory of cognition', cf. Friston, 2010).

In experimental psychology, predictions are induced most often by either presenting precues that in most cases precede a certain event but sometimes are followed by another, therefore unexpected event, by presenting events in a certain sequence that is occasionally violated, or by varying the relative frequency of events. In any of these cases, it is the 'validity' of information as conveyed by the precues, the regularity or the proportions that is assumed to be the main driver of predictions. In contrast to validity, the 'nature of predictions', that is, the role predictions play in the context of a certain behavior, is a comparatively neglected issue (cf. Bubic, von Cramon, & Schubotz, 2010, for a discussion of different kinds of predictions). In the present study, we compare two kinds of predictive behavior, namely guessing and choosing, that we situated into a largely identical task context.

Our starting point consisted of a series of task switching studies investigating how predictions affect the efficiency of switching among simple cognitive tasks (Kleinsorge & Scheil, 2015). Our main finding was that incorrect predictions (which were based on guessing) hampered the performance of task repetitions more than the performance of task switches, resulting in a reduction of switch costs. This was true when participants were asked to guess the upcoming task (Kleinsorge & Scheil, 2015, Exp. 1 & 2), but also when they guessed the lateral position of the next precue (Exp. 3). The latter observation is important because it rules out an account in terms of a disruption of repetition-based facilitation (for details, cf. Kleinsorge & Scheil, 2015). Thus, it seems that irrespective of which task feature a guess relates to, incorrect guesses result in compensatory adjustments that facilitate switching from one task to another.

In a follow-up study (Kleinsorge & Scheil, 2016), we compared this effect of predictions based on guessing with predictions based on choosing when not all choices were actually granted. In particular, we instructed different groups of participants to either guess or choose the upcoming task, which conformed to participants' guesses or choices in 75% of the trials. In the guessing condition, we replicated our earlier finding of an interaction of expectancy and switching, that is, we again observed a reduction of switch costs in trials with incorrect guesses as compared to correct guesses. In contrast, when participants chose the next task, the difference between granted and denied choices was equivalent across task repetitions and switches. Thus, no reduction of switch costs induced by denied choices was observed. We interpreted these observations as indicating that the instruction given to

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participants of the choosing conditions, which included truthful information regarding the proportion of granted and denied choices, provided them with a veridical model of the overall situation that was actually corroborated by a certain proportion of denied choices. This was different for participants of the guessing condition who were told that the tasks would be chosen randomly, so an incorrect guess was simply an incorrect guess that resulted in a mismatch between the predicted and the actual task. Put otherwise, whereas participants in the choosing condition were provided with information that allowed them to attribute a denial of choice to a known regularity in the environment, participants in the guessing instruction probably attributed a wrong guess to their own behavior ('I was wrong.') and tried to compensate for their failure.

So far, our observations demonstrate a reliable functional difference between guessing and choosing an upcoming task in terms of the behavioral effect of an unexpected task: Whereas an incorrectly guessed task is associated with reduced switch costs, this is not the case with a denied task choice. However, at present it remains somewhat elusive which difference between the guessing and choosing conditions caused these different outcomes of unexpected tasks.

The guessing and choosing conditions of Kleinsorge and Scheil (2016) differed not only with respect to what participants were instructed to do (guessing versus choosing). In addition to this, these instructions provided participants with models of the experimental situation that differed largely with respect to the degree to which these models corresponded to reality. Whereas the information given with the choosing instruction corresponded closely to reality, the information given with the guessing instruction deviated from reality in two respects. First, the notion of 'guessing' suggested to participants that the identity of the actual task did not depend on their guess – this is what 'guessing' is about. Furthermore, the proportion of correctly guessed tasks largely exceeded the proportion to be expected from real guessing. Although we had observed a reduction of switch costs by incorrect guesses across a range of expectedness proportions between 0.33 (Kleinsorge & Scheil, 2015, Exp. 1 & 2) and 0.75 (Kleinsorge & Scheil, 2016), the additive effect of task expectedness and switching observed with choosing instructions was only observed with an expectedness proportion of 0.75 so far. Thus, in this study, the variation of instruction was confounded with a certain amount of disparity in terms of the generative structure of the experimental environment as suggested by the instruction and the actual contingencies. In the present experiment, we implemented a range of proportions of expected tasks within both types of instructions. With guessing instructions, the higher the proportion of expected tasks, the less the actual environment corresponded to a real guessing situation. With choosing instructions, the lower the proportion of expected tasks, the less the actual environment corresponded to a real choosing situation. This way, we varied the match between the generative structure of the environment with the semantics of 'guessing' and 'choosing'. What remained as the essence of the difference between guessing and choosing was that with choosing instructions, participants were provided with a veridical model of the generative structure of the environment, whereas with guessing instructions, participants were led to assume that the environment would behave in a random manner.

Our choice of different expectedness proportions within each type of instructions was constraint by certain limits of plausibility. For example, combining a proportion of only 50% expected trials with a choosing instruction would almost certainly induce participants to disbelieve the instruction. Likewise, combining a proportion of 80% expected trials with a guessing instruction would almost certainly prevent participants from believing that they are really guessing. However, there should be a certain range of 'plausible variation' within each type of instruction that allows for testing inasmuch functional differences between guessing and choosing are really driven by the instruction instead of a particular combination of instructions with expectedness proportions.

Therefore, in the present study we ran an extended replication of the experiment of Kleinsorge and Scheil (2016) that included a variation of the proportion of (in)correct guesses and granted versus denied choices. This proportion was varied across three levels in the guessing and choosing conditions. Two of these levels (60 and 70% expected tasks) were realized with both guessing and choosing instructions. This was complemented by a condition with 50% correct guesses and a condition with 80% granted choices aiming at maximizing the fit between the mind sets induced by the guessing and choosing instructions, respectively, and the probabilistic structure of the situation.

In our view, what remains at the heart of the distinction between guessing and choosing across such variations on the level of (mis)match between instruction and the proportion of expected tasks is the availability of a model of the generative structure of the environment. With choosing, one gets what one has chosen, but only on a certain proportion of trials. Denied choices are to be expected and corroborate rather than challenge this model of the environment. With guessing, in contrast, incorrect guesses are also to be expected, but there is no overall model that allows for an integration of this information beyond knowing that the environment is generally unpredictable. Of course, it is possible that the frequency of correct and incorrect guesses becomes integrated in a bottom-up manner. In this case, the variation of expectedness proportion should become critical. If, however, it is the (un)availability of an overall model of the generative structure of the environment that matters, the differences between guessing and choosing should be largely unaffected by variations of expectedness proportion.

Therefore, in line with our assumption that the differences between the guessing and choosing conditions observed by Kleinsorge and Scheil (2016) were mainly due to differences regarding the representation of the overall situation (including the (un)availability of an overall model subsuming a certain proportion of unexpected tasks), we expected to replicate our original observation of a switch-cost reduction with unexpected tasks in the guessing but not in the choosing condition. Furthermore, we wanted to explore eventual modulations of this pattern by the proportion of tasks conforming to predictions. Such modulations would indicate some 'penetration' of the instruction-based mind set by the probabilistic structure of the environment. Of course, another possible outcome would be that the way predictions modulate the efficiency of task switching is mainly driven by this probabilistic structure. In this case, our original assumptions regarding functional differences between guessing and choosing would turn out to be misguided.

2. Method

2.1. Participants

The original sample consisted of 144 right-handed participants with normal or corrected-to-normal vision. They were assigned alternately to one of six groups in the order of their appearance. 33 participants who produced > 15% erroneous or invalid trials were excluded. Invalid trials are trials in which participants dropped the key to indicate the upcoming task too early, resulting in error feedback and trial termination. Because some conditions of our experiment represented relatively rare events by definition, such high proportions of invalid or erroneous trials were almost inevitably associated with a number of empty cells. In addition, 8 participants who guessed or chose < 10% or > 90% task switches were excluded. The same holds for five participants who did not comply with the instructions or who did not complete the experiment. The final sample consisted of 96 participants (25 male) with a mean age of 23.1 years (range: 19–30). The number of participants per group ranged between 16 and 18.

2.2. Stimuli, tasks, and apparatus

Imperative stimuli consisted of digits from range 1–9 (excluding 5)