Response to Novelty Correlates with Learning Rate in a Go/No-Go Task in Göttingen Minipigs

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SUMMARY

Novelty-seeking and harm-avoidance personality traits influence Go/No-go (GNG) learning in humans. Animal studies have also indicated a link between response to novelty and spatial discrimination learning. In the present study, we test the hypothesis that learning rate in a GNG task correlates with the behavioral response of Göttingen minipigs to novelty. In a group of 12 minipigs of mixed genders, response to novelty was measured by numbers of contacts with a novel object, and the total duration of exploration of the novel object. These parameters were correlated to individual learning rate in a GNG task. The number of sessions to reach criterion in the GNG task correlated significantly with the number of contacts to a novel object \( r = 0.70, p = 0.03 \), but not with the duration of object exploration \( r = 0.29, p = 0.41 \). Thus, pigs with a low behavioral response to novelty learned the GNG task faster than did pigs with a strong behavioral response to novelty, indicated by the tendency to approach novel objects.

We hypothesize that the critical factor in this relation is difference in emotional reactivity rather than difference in motivation for exploration. In conclusion, in addition to ‘cognitive’ ability, ‘temperamental’ factors are likely to influence learning in individual pigs.

KEYWORDS

pig, swine, emotional reactivity, temperament

INTRODUCTION

We are currently investigating the potential of using the standardized purpose-bred laboratory pigs as a supplement to exiting rodent and monkey models within behavioral neuroscience. In this context, we recently established a Go/No-go (GNG) task in Göttingen minipigs (Moustgaard et al., 2005). Informal observation of pigs suggested that fearful animals learned the GNG task faster than less fearful animals. This observation inspired the present preliminary study in which the role of ‘temperament’ in learning was studied in pigs. Although the interest in studying the role of “temperamental” factors in learning is increasing, the issue has been addressed in relatively few studies. In humans, the trait of extraversion predicts
the commission of relatively more passive avoidance errors (Patterson et al., 1987). It has also been suggested, however, that individual differences in performance of GNG discrimination is associated more with anxiety than with extraversion (Zinbarg & Revelle, 1989).

Early animal studies showed a link between locomotor activity in response to novelty and the learning rates in active- and passive avoidance tasks (Delacour & Santacana, 1967). Later studies showed that individual responses to novelty in young rats might be predictive of cognitive impairment later in life (Dellu et al., 1994). Furthermore, individual rats differ in their susceptibility to stress-induced impairments in spatial learning tasks, the impairments being sensitive to reactivity to novelty (Touyarot et al., 2004). Nevertheless, emotional reactivity did not correlate with learning rate in spatial discrimination tasks in rats (Blokland & Raaijmakers, 1993) or with general cognitive ability in mice (Galsworthy et al., 2002).

Before undertaking the present study, we had observed informally that fearful pigs learned a GNG task more rapidly than non-fearful pigs. Insofar as the tendency to approach and explore a human being corresponds to the tendency to investigate a novel non-living object (Janczak et al., 2003), we hypothesized that learning the GNG task in minipigs could be predicted from their response to novelty, an index of 'temperament' (Dellu et al., 1996). Therefore, we performed novelty tests in the group of minipigs that had already been trained in the GNG task. We subsequently tested the correlation between individual behavioral response to novelty and learning rate in the GNG task.

**EXPERIMENTAL**

All procedures in this study were performed in accordance with the Danish Animal Experimentation Act (based on the Council of Europe Convention ETS 123) under a license granted by the Ministry of Justice. The study group consisted of six male and six female adult Göttingen minipigs (Dalmose, Denmark) weighing 17–24 kg. The animals were housed in groups of two males and two females in pens supplied with shavings and straw. The animals were fed restrictedly with a commercial pellet diet for minipigs (Altromin (Brogaarden, Denmark)). Water was provided ad libitum.

**Behavioral methods**

At 6 months of age, the animals were trained in the GNG task as described elsewhere (Moustgaard et al., 2005). In brief, acquisition of the task was obtained in a sound-proof booth by registering the number of correct or incorrect responses to a visual stimulus displayed on a computer screen, which was positioned near the bottom of two response holes. Responses were registered automatically by a light beam inside the response-holes, which was connected to an automated feeder delivering a reward (M & M chocolate) upon correct responses, and to a light-switch, which turned off the electric light for 20 sec upon incorrect responses. A blue stimulus displayed in either of the response holes signaled 'go', and the correct response was a response in either hole, whereas a red stimulus signaled 'no-go', for which there should be no response. The pigs were trained in daily sessions of 100 trials until a behavioral criterion of less than 11 total errors (commission plus omission errors) in each of two consecutive sessions was reached.

At 9 months of age, the animals were subjected to a novel object test (NT), the methodology of which has been described elsewhere (Lind et al., 2005). In brief, the NT took place in a 2.00 × 3.15 m familiar test-arena that was cleaned between tests. After a 5-minute habituation period, the test was initiated by presentation of a novel object (20 × 9
cm plastic water-atomizer) in the center of the arena. The number of physical contacts to the novel object during 5 min and the total time spent in contact with the object were recorded. The animals were habituated to the testing situation after three earlier exposures to this test (but using different objects).

**Data analysis**

Correlations were assessed with Spearman’s Partial Rank Correlation Coefficient with gender partialled out. Student’s T-test was used to assess group differences in measures obtained in the NT. One pig that stopped responding during training was excluded from the study.

**RESULTS AND DISCUSSION**

The learning curve of the GNG task has been published elsewhere (Moustgaard et al., 2005). In the NT, the recorded numbers of contacts to the novel object (females: 9.5 ± 2.8; males: 9.4 ± 0.9) did not differ between genders. The duration of contact with the novel object, however, was significantly lower (t = 3.2, df = 9, p = 0.01) in females (66.3 s ± 45.1 s) than in males (157.2 s ± 47.9 s). The number of sessions required to reach criterion in the GNG task correlated significantly with the number of contacts to a novel object (r = 0.70, p = 0.03) (Fig. 1), but not to the duration of exploration of the novel object (r = 0.29, p = 0.41).

The present study was carried out to obtain a preliminary indication of whether individual dif

![Fig. 1: Relation between individual number of contacts to a novel object in a novel object test and number of sessions to reach the behavioral criterion in a Go/No-go task in a cohort of 11 Göttingen minipigs (r = 0.70, p = 0.03). Two male pigs have exactly the same values and therefore cannot be separated from each other on the graphic presentation (values: 10 contacts with the novel object and 20 sessions to reach criterion in GNG task).](image)
ferences in ‘temperament’ contribute to differences in the rate of learning a GNG task in a group of Göttingen minipigs. We found that the individual number of sessions to reach the learning criterion in the GNG task correlated significantly and positively with the number of contacts to a novel object in a NT. This result implies that individual pigs with a low exploratory response to novelty learned faster than did pigs with strong exploratory response to novelty.

In a factor analysis of pig open field- and novelty test behavior, the tendency to explore a novel object is loading on a specific factor, suggesting that the exploration of novel objects is independent of the tendency to explore the environment (Thodberg et al., 1999). Furthermore, the number of contacts to a novel object is behaviorally distinct from the duration of exploration of the novel object. This finding can be related to the distinction between inquisitive versus inspective exploration (Dellu et al., 1996; Berlyne, 1960). The inquisitive exploration is connected to emotional reactivity, as indicated by a study showing that a less anxious strain of mice made significantly more approaches toward a novel object than did a more anxious strain (Podhorna & Brown, 2002). So-called ‘reactive’ pigs also have higher initial levels of passive avoidance, whereas ‘proactive’ pigs approach a novel stimulus more quickly (Janczak et al., 2003). Therefore, the presently indicated impact of reactivity to novelty on learning rate in a GNG task for minipigs could be emotionally based to a large extent, rather than being based upon motivation for exploration. This interpretation would agree with an earlier report of discrimination learning and reversal in pigs, in which the group of pigs having lowest scores on emotionality performed worse than the group of pigs with highest scores on emotionality (Lien & Klopf, 1978).

The results of the present study make it likely that emotional reactivity influences GNG learning also in pigs. Future studies could address this hypothesis by the use of specific tests for measuring anxiety in pigs (Andersen et al., 2000). Furthermore, future investigations are warranted to address how ‘temperamental’ and emotional factors influence learning in pigs and in other laboratory animals and the role played by the learning paradigm/experimental set-up in this context. More specifically, we plan to follow up on the present study by investigating the possible correlations between a broader variety of cognitive and behavioral measures in pigs. Finally, because the results of the novelty test could be influenced by prior discrimination learning and prior experience with the novelty test, the impact of this factor on the present findings should be investigated.

Viewed in a broader context, the present study could contribute to understanding how emotion and cognition control behavior. Although a highly debated area, seen from a neurobiological perspective, tight emotion-cognitive interactions are evident (Gray 2004; Dolan 2002, LeDoux, 1995). Our results support this notion. Yet, exactly how these interacting systems are integrated as behavioral control states remains elusive. From the present study we can only speculate on how emotion could possibly affect learning and to what extend this effect is caused by impacts on, for example, attention or memory processes. Non-cognitive factors, like emotional sensitivity to the switch-off of the electrical light upon incorrect response, are also likely to have affected the learning rate. Further investigations of the psychological and neurobiological mechanisms behind the present results are therefore warranted.

In summary, we found that individual behavioral response to novelty correlates with learning rate in a GNG task for minipigs. We hypothesize that the critical factor in this relation is individual differences in emotionality rather than differences in motivation for exploration. As the results of the study imply that the learning rate in pigs could be influenced not only by individual differences in ‘cognitive’ ability but also by
‘temperamental’ factors, to what extent different temperament factors affect GNG learning in pigs should be investigated further. Furthermore, investigation of the role of different ‘temperamental’ factors in learning across multiple learning situations in pigs is warranted.

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