Differential retention of predator recognition by juvenile rainbow trout

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Summary
There is a wealth of studies that have examined the way in which prey animals acquire information about their predators, yet the literature on how long prey retain this information is almost non-existent. Here, we investigated if the memory window associated with learned recognition of predators by juvenile rainbow trout was fixed or variable. Specifically, we tested whether the retention of predator recognition was influenced by the risk level associated with the predator. We conditioned juvenile trout to recognize predatory pumpkinseed sunfish posing a high, low or no threat and tested their response to the predator after either 1 or 8 days, and found that trout responded to the odour of the pumpkinseed longer if the risk associated with the predator was higher. We discuss the way in which memory associated with predator risk information provides fundamentally different costs/benefits trade-offs than those associated with foraging.

Keywords: predator recognition, memory, threat-sensitivity, learning, rainbow trout \textit{Oncorhynchus mykiss}.

Introduction
To be successful, prey animals have to decrease the possibility of being eaten by predators while maximizing foraging and reproduction (Lima & Dill,
To optimize this trade-off, prey have to maintain accurate and reliable information about the risk associated with potential predators, which allows them to display adaptive, threat-sensitive antipredator responses (Helfman, 1989; Chivers et al., 2001). One way that prey gather information about their predators is through learning. Whether the information is acquired through personal experience (direct learning) or through conspecifics (social learning), prey learn not only to recognize the identity of the predator but also the level of risk posed by the predator (e.g., Ferrari et al., 2005, 2007). However, the risk posed by predators may fluctuate through time (Sih, 1992). Hence, as time passes, the reliability of the learned information may decrease. In other words, the uncertainty associated with the risk of the predator increases if the prey cannot obtain updated information regarding the status of that predator. While hundreds of studies have investigated ways in which prey gather information about their predators, very little is known about the way in which prey species use information learned about their predators as time goes on and the uncertainty associated with the predator cues increases (Ferrari et al., 2010a).

Contrasting with the sparse record of predation studies, a number of theoretical and empirical studies have looked at the concept of memory and forgetting in a foraging context (McNamara & Houston, 1987; Stephens, 1987; Hirvonen et al., 1999; Dall & Johnstone, 2002). McNamara and Houston (1987) provided an early model for which optimality of information use was dependent on the rate at which the environment was changing. If the environment was constant, then all pieces of information regarding the value of a foraging patch should be used in the decision process and they should be given equal weight. However, if the environment was rapidly changing, then recent, accurate information should weight more in the decision process, while older information should weigh less. It was assumed that the individual had a given memory window, and all information outside of this window were not used in the decision process, and were considered ‘forgotten’. Hirvonen et al. (1999) suggested that the size of this memory window should not be fixed, but flexible. They proposed that the size of the memory window should be dependent on the payoffs associated with the use of the information. In other words, a good payoff, that is, a good correlation between the information and the food reward, would result in the memory window being extended, and the information used for longer. Conversely, a poor payoff, that is, poor or no correlation between the information and the food reward,