Journal Club

Editor's Note: These short, critical reviews of recent papers in the *Journal*, written exclusively by graduate students or postdoctoral fellows, are intended to summarize the important findings of the paper and provide additional insight and commentary. For more information on the format and purpose of the Journal Club, please see http://www.jneurosci.org/misc/ifa_features.shtml.

Second Language Feedback Reduces the Hot Hand Fallacy, But Why?

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Review of Gao et al.

A great deal of recent research has indicated that individuals evaluate their environments differently in a second language than in their native tongue. From noticing the finest of perceptual differences such as color (Athanasopoulos et al., 2010) to the categorization of types of objects (Boutonnet et al., 2013), it seems that the language in which an evaluation is made has a significant impact on both the cognitive content and the physiological representation of the evaluation. Recently, researchers have discovered that using a foreign language diminishes certain well known cognitive biases such as framing effects, in which one of two equivalent outcomes is consistently preferred merely because it is positively presented or “framed” (Keysar et al., 2012; Costa et al., 2014). The most common explanation of this “foreign language effect” is that, compared with a learned second language, one’s mother tongue is more colored by emotional and stereotypical associations that may lead to reasoning errors. Therefore, when cognitive biases are primarily caused by strong emotional responses, thinking in a second language

may provide a sort of debiasing—a way for reasoners to generate normative responses more consistently. However, emotions exert a complex and sometimes unpredictable influence on different reasoning biases. For example, although emotional arousal has been linked to decreased performance on logic questions in general (Blanchette and Leese, 2011), Goel and Vartanian (2011) found that negative emotions can attenuate the effects of belief bias that would otherwise lead reasoners astray on noncredible but true syllogisms.

To explore the interaction between language context and biases resulting from the sequential accrual of information, Gao et al. (2015) analyzed the “hot hand” effect, the canonical example of which is found in basketball: a player who makes a few shots in a row might believe his likelihood of making the next one is higher than he would have otherwise. Although there is minimal (and very mixed) evidence suggesting that experts occasionally do have clusters of superior performance (Gilovich et al., 1985; Avugos et al., 2013), such a belief is certainly a fallacy when it emerges in truly random contexts. Believing, for example, that one has a hot hand after recent successes with rolling a fair set of dice is unreasonable. The next roll is every bit as likely to bust as any other.

Gao and his team (2015) presented participants with a series of gambles that were either safe or risky. The researchers’

primary innovation was to give participants feedback in their native language (Chinese) or a second language they knew (English) while monitoring behavioral and EEG outcomes. On the assumption that operating in their second language would lower their emotional sensitivity, the authors hypothesized that participants receiving feedback in their second language would be less likely to fall for the hot hand fallacy; in other words, in a second language, participants would be less likely to overestimate positive outcomes when confronted with risky gambles after just receiving positive feedback. The researchers also anticipated that smaller feedback-related negativities (FRNs) would appear in EEG recordings when feedback was provided in English because other studies have linked the amplitude of the FRN to outcome valence (Hajcak et al., 2006; Holroyd et al. 2006). The authors also evaluated the P300, a positive deflection in the time-locked EEG signal that emerges ~300–400 ms after stimulus presentation and is thought to reflect high-level cognitive processes (i.e., attentional resources, memory updating; Polich, 2007); however, because of the offset anticipated in the FRN, they had no particular predictions about the P300.

Event-related potentials (ERPs) were recorded and used to contrast the impact of feedback on the various trials the participants worked through, which differed by language, valence, and type. There were two types of gambles: safe gambles con-

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sisted of a 50/50 chance of gaining a certain sum of money and no risk of losing anything, whereas risky gambles were composed of one of a set of possible gains (+100, +80, +60, +40, and +20) and one of a set of possible losses (−50, −40, −30, −20, and −10), with both elements chosen randomly. Here, too, each outcome was equally likely, which participants knew. After each gamble, participants received feedback in Chinese or English—phrases after positive or negative outcomes such as “Great!” or “Terrible!”—before being shown the outcome of the gamble and they were then able to opt into subsequent gambles. After completing eight blocks of 55 trials, four in Chinese and four in English, participants rated the English and Chinese feedback terms for valence, arousal, and familiarity and none of these measures were significantly different, suggesting that the translations were approximately equivalent and likely not the primary source of the observed effects.

The behavioral differences between first and second language feedback are striking, and these alone constitute a substantial addition to research on the foreign language effect. Using a binary logistic regression, the authors evaluated participants' decisions to play or leave a given gamble with the following regressors: language of feedback, magnitude of prospective gains and losses, and outcome of the preceding trial. When participants received English feedback, they tended to take fewer gambles than when they received the feedback in Chinese ($\beta = -0.17$ (0.06), $p < 0.01$). Moreover, the interaction between feedback valence and language was significant: participants receiving positive English feedback were less likely to gamble than those receiving similar Chinese feedback ($\beta = 0-0.48$ (0.15), $p < 0.01$).

Using a straightforward ERP method, the authors provide similarly impressive physiological evidence. The FRN for Chinese was significantly more pronounced than for English ($F_{(1,15)} = 7.65$, $p < 0.05$), whereas the P300 was significantly enhanced for English compared with Chinese feedback ($F_{(1,15)} = 6.66$, $p < 0.05$), indicating that the physiological correlates of processing the two different feedback languages are at least quantitatively differentiable. Interestingly, language and valence interacted in both ERP components: in Chinese, the FRN dissociated positive and negative feedback, but it did not in English (Chinese–English = 1.02 μV , $p < 0.01$); conversely, in English, but

not in Chinese, the P300 dissociated the valence of the feedback (Chinese–English = $-0.95 \mu V$, $p < 0.01$).

The foregoing results provide an exciting entry point into evaluating processing differences among polyglots and leave open two alternative interpretations. First, the behavioral modulation of risk taking that the authors found might be more related to the processing demands of a second language than to differences in emotional sensitivities between native and foreign languages. Indeed, as non-native English speakers, Chinese participants probably need additional cognitive resources to process English compared with their own language. This is consistent with Berken et al.'s (2015) demonstration that reading in a second language results in greater right anterior cingulate cortex activation than reading in a native tongue even among highly proficient second language users.

Supporting this interpretation, Gao et al. (2015) found that responses were generally slower in English and the P300 was greater for English feedback. The P300 has been linked recurrently to resource allocation: as more resources are needed, the P300 increases (Polich, 2007; Wu and Zhou, 2009). Its level is also correlated with reaction times in Gao et al.'s (2015) study, as well as in other studies (Balconi and Canavesio, 2015), lending additional support to the present proposal. By this account, increased processing and related slowing might be implicated in the behavioral and physiological differences that the authors report as much as the actual emotional salience of the language of presentation. Furthermore, although Gao et al. (2015) evaluated response latency as a dependent variable, they did not include latency as an explanatory variable in their primary binary logistic regression. They noted, however, that response latency correlates with language and participants took more time in the English feedback condition. These slower response times could promote more prudent choices and implicitly discourage hot hand reflexes. One could strengthen the hypothesis that emotionality was the relevant difference between English and Chinese conditions by coregistering alternative physiological–emotional measures and EEG outcomes to better characterize foreign language effects. For example, Harris et al. (2003) have proposed a useful method of qualifying the emotional impact of interpreting certain terms in a foreign language using skin conductance, finding that emotionally freighted terms are consistently

less arousing in the second language. Such a method could easily be adapted to the current investigation.

A second alternative interpretation of the authors' results merits attention. The authors use the FRN to index reward value outcomes. Although much research has suggested that the FRN dissociates negative from positive outcomes (Hajcak et al., 2006; Holroyd et al., 2006), recent evidence suggests that it also encodes expectations. Manipulating expectation of reward and reward magnitude in a monetary gambling task, Wu and Zhou (2009) found that the FRN was enhanced by violations of one's expectations, concluding that it may function as “a general mechanism that evaluates whether the outcome is consistent or inconsistent with expectation” (see also Pfabigan et al., 2011).

Gao et al. (2015) found both increased hot hand effects and a greater FRN for negative outcomes in the participants' first language. The interpretation of the FRN as reflecting a violation of one's expectations unites these two findings: after repeated sequences of positive outcomes, participants were more likely to expect further positive outcomes in Chinese and thus evidenced greater FRN amplitudes. One way to distinguish these interpretations is to record ERP signals while manipulating both feedback valence and expectations orthogonally in the two different languages by varying the probability of the outcomes (Talmi et al., 2013). For example, in one block, participants could be surprised with a positive outcome in a context in which negative outcomes are more probable, whereas a subsequent block might do the contrary. Such a paradigm would determine whether the recorded FRN differences between one's native and a foreign language are primarily picking up on differences in expectation violations or in feedback valence.

Gao et al. (2015) provide powerful new evidence of a foreign language diminishing a common cognitive bias. Their solid behavioral and physiological results are naturally interpreted in terms of a diminished emotional sensitivity in one's second language, yet there are appealing alternatives. Although much remains to be clarified, Gao et al. (2015) have generated exciting results that extend the literature on foreign language effects and may well lead to successful debiasing strategies.

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