



## Cultural background influences implicit but not explicit sense of agency for the production of musical tones



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### ABSTRACT

The sense of agency is suggested to occur at both low and high levels by the involvement of sensorimotor processes and the contribution of retrospective inferences based on contextual cues. In the current study, we recruited western and non-western participants and examined the effect of pleasantness of action outcomes on both feeling of control ratings and intentional binding which refers to the perceived compression of the temporal delay between actions and outcomes. We found that both western and non-western groups showed greater feeling of control ratings for the consonant (pleasant) compared to dissonant (unpleasant) outcomes. The intentional binding effect, on the other hand, was stronger for the consonant compared to dissonant outcomes in the western group only. We discuss the results in relation to how cultural background might differentially influence the effect of outcome pleasantness on low and high levels of the sense of agency.

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### Introduction

The sense of agency refers to the subjective experience that accompanies our actions; it is the sense that one has control over their actions and their consequent outcomes. Recent research has suggested that the nature of the mechanism behind how we experience the sense of agency is not only driven by the internal/sensorimotor processes but also influenced by environmental and contextual factors.

It has been proposed, for example, that agentic experience might occur at two levels (Synofzik, Vosgerau, & Newen, 2008). The low level feeling of agency is described as a pre-reflective (Gallagher, 2000) and non-conceptual experience of agency. This low level sense of agency is proposed to emerge from sensorimotor processes (Synofzik et al., 2008), including the matching between predictions produced by an internal forward model and actual consequences of actions (Blakemore, Wolpert, & Frith, 2002; Frith, 2005; Frith, Blakemore, & Wolpert, 2000). At a higher level, the agentic experience emerges as an explicit or reflective judgment which is driven by inferences, beliefs, and contextual cues (Bayne & Pacherie, 2007; Moore, Middleton, Haggard, & Fletcher, 2012; Obhi & Hall, 2011a; Synofzik et al., 2008; Wegner, 2003; Wegner, 2004; Wegner & Wheatley, 1999).

In experimental settings, the sense of agency has been measured by obtaining self reports of participants' subjective feeling of control over their actions or outcomes (Balslev, Cole, & Miall, 2007; Ebert & Wegner, 2011; Linser & Goschke, 2007; Metcalfe & Greene, 2007; Sato & Yasuda, 2005; Sebanz & Lackner, 2007; Wegner & Wheatley, 1999; Wenke, Fleming, & Haggard, 2010). Alternatively, the intentional binding effect has been used as an indirect measure of the sense of agency (Barlas & Obhi, 2013; Haggard, Clark, & Kalogeras, 2002; Haggard, Poonian, & Walsh, 2009; Moore, Wegner, & Haggard,

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2009; Obhi & Hall, 2011a; Obhi & Hall, 2011b; Obhi, Swiderski, & Farquhar, 2013; Wohlschläger, Haggard, Gesierich, & Prinz, 2003). Intentional binding refers to the perceived attraction between the timing of actions and the onset of their consequences (Haggard et al., 2002), and has been suggested to index the experience of agency (see Moore & Obhi, 2012, for a review on intentional binding).

Recent findings have suggested that the intentional binding effect can be influenced by several contextual and situational factors. It has been shown, for example, that the intentional binding effect was reduced when memories involving in depressive life periods are activated compared to the recollection of relatively neutral events (Obhi et al., 2013). In another study, it has been shown that causal beliefs regarding the source of the actions resulted in the stronger binding effect when participants believed that they produced the outcomes compared to when they believed that another person was the cause (Desantis, Roussel, & Waszak, 2011).

One important question regarding the agentic experience concerns situations where actions generate outcomes that differ in their perceived pleasantness. Recent studies have shown, for example, that negative action outcomes had an attenuating effect on intentional binding compared to positive or neutral outcomes (Takahata et al., 2012; Yoshie & Haggard, 2013). Similarly, priming participants with positive pictures compared to neutral ones was found to increase the intentional binding effect (Aarts et al., 2012).

A critical extension to this question is whether perceived pleasantness can affect the sense of agency differentially based on potential cultural variations. In the current study, we targeted at this question and examined how intentional binding and the explicit feeling of control over action outcomes would be influenced when these outcomes differed in terms of their perceived pleasantness, which is potentially shaped by cultural differences.

As action outcomes, we used consonant and dissonant piano chords that have long been subject to the study of music perception by the different sensations they evoke in listeners. According to the Pythagorean view, the relative simplicity of the frequency ratio of two tones played simultaneously determines the pleasantness of the outcome sound (Helmholtz, 1877; Tenney, 1988). Consonance, in this regard, refers to the pleasantness produced by the co-occurrence of two tones whereas dissonance is described as unpleasant due to the beating and roughness (Dell'Acqua, Sessa, Jolicœur, & Robitaille, 2006; Dellacherie, Roy, Hugueville, Peretz, & Samson, 2011; Plantinga & Trehub, 2013; Shapira-Lots & Stone, 2008). The major view regarding the perception of these tonal structures suggests that the stability and pleasant-sounding attributes make consonance preferred over instable and rough-sounding dissonance (Bidelman & Krishnan, 2009; McDermott & Hauser, 2004).

However, the issue regarding the relationship between psychological and neurophysiological basis of consonance preference and its universal prevalence remains unresolved. One contention is that preference for consonance is innate and is due to certain constraints in the auditory system (Schellenberg & Trehub, 1996; Tramo, Cariani, Delgutte, & Braida, 2001). In support of this view, studies with infants measuring their looking-time preference suggests that infants as young as 2 and 4-month-olds (Trainor, Tsang, & Cheung, 2002) and 2-day-olds (Masataka, 2006) prefer to listen to consonant excerpts over dissonant ones. However, there is also accumulating evidence suggesting that consonant preference is the product of learning mechanisms. Vassilakis (2005), for example, examined Middle Eastern, North Indian, and Bosnian musical structures and noted that beats, which are thought to reside in dissonance, are well accepted in the musical structure of these cultures. In addition, Plantinga and Trehub (2013) tested consonance preference among 6-year-old infants and found that the listening time to the consonant chords was not longer than dissonant ones. Moreover, they showed that after a 3-min exposure to either consonant or dissonant stimuli, infants listened to the familiar intervals longer, regardless of their consonant or dissonant status.

The current study takes into account both lines of findings suggesting enhanced sense of agency over positive outcomes and cultural variances in the perceived pleasantness of consonance to address two important questions. First, these two types of stimuli would allow us to investigate whether low and high levels of the sense of agency are similarly affected by the pleasantness of action outcomes. Second, as consonance preference is suggested to vary across different cultures (e.g. Vassilakis, 2005), our design could reveal whether this variance can manifest itself on either low or high levels of the sense of agency.

In the current study, participants completed a computer based task in which they made a voluntary right or left key press which was followed by either consonant or dissonant piano chords. We determined the intentional binding effect, subjective feelings of control over the chords, and participants' ratings for how much they liked each of consonant and dissonant chords.

Based on the common bias towards attribution of the self as a cause of positive outcomes (Campbell & Sedikides, 1999), we predicted that the perceived pleasantness of consonant chords would produce higher feelings of control and liking ratings as well as stronger binding effect (Yoshie & Haggard, 2013) compared to the dissonant ones. As consonant and dissonant chords are based specifically on western tonal structure, our second prediction was that we would observe a greater effect of consonance in the western group compared to the non-western group.

## Method

### Participants

In total, thirty-four right-handed participants were recruited from the participant pool of Wilfrid Laurier University. The study was approved by the Research Ethics Board of Wilfrid Laurier University, and all participants gave written informed consent prior to beginning the study. We excluded four participants who, in at least one condition, had their mean judgment

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