Recollecting Cross-Cultural Evidences: Are Decision Makers Really Foresighted in Iowa Gambling Task?

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The Iowa Gambling Task (IGT) has become a remarkable experimental paradigm of dynamic emotion decision making. In recent years, research has emphasized the “prominent deck B (PDB) phenomenon” among normal (control group) participants, in which they favor “bad” deck B with its high-frequency gain structure—a finding that is incongruent with the original IGT hypothesis concerning foresightedness. Some studies have attributed such performance inconsistencies to cultural differences. In the present review, 86 studies featuring data on individual deck selections were drawn from an initial sample of 958 IGT-related studies published from 1994 to 2017 for further investigation. The PDB phenomenon was found in 67.44% of the studies (58 of 86), and most participants were recorded as having adopted the “gain-stay loss-randomize” strategy to cope with uncertainty. Notably, participants in our sample of studies originated from 16 areas across North America, South America, Europe, Oceania, and Asia, and the findings suggest that the PDB phenomenon may be cross-cultural.

Keywords: iowa gambling task, IGT global map, foresight, prominent deck B phenomenon, gain-loss frequency, gain-stay loss-randomize decision strategy, cross-cultural, dynamic decision-making

INTRODUCTION

In recent decades, the Iowa Gambling Task (IGT; Bechara et al., 1994) has gradually become a classic experimental paradigm of dynamic decision making (Dunn et al., 2006) and has even been used to clinically assess patients with ventromedial prefrontal cortex (vmPFC) dysfunction related to brain lesions (Bechara, 2007, 2016). The IGT is a dynamic task that simulates the uncertain conditions of a real-life situation. In the task, four decks are displayed with a pseudorandomized and symmetrical gain-loss schedule that is not disclosed to the participants. Based on the schedule developed by Bechara et al. (1994), decks A and B are defined as “bad decks” due to their long-term disadvantageous outcome despite a large gain (e.g., $100) in each selection, while decks C and D are scheduled with a small gain (e.g., $50) in each selection and defined as “good decks” due to their long-term advantageous outcome. Furthermore, decks A and C contain five times as many losses, while decks B and D contain an average of only one loss for every 10 trials. Compared
to patients with vmPFC lesions, Bechara et al. (1994) theorized that control participants would form a “somatic marker” (Damasio, 1994) when making deck selections and that the gut feeling related to the somatic marker would lead to foresighted and rational decision making—that is, choosing “good decks” (C and D) in the IGT. Moreover, a series of studies by Bechara et al. (1994; 1997; 1998; 1999; 2000) replicated these results.

However, Dunn et al. (2006) undertook a review of IGT-related studies and noted several possible issues, including the possibility that the inconsistencies identified between prior studies’ findings were due to variability of the normal (control) participants. Recently, though, others have shown that the IGT participants in control groups typically favor bad deck B not only more than deck A, but also more than good decks C or D (Wilder et al., 1998; Toplak et al., 2005; Fernie and Tunney, 2006; Lin et al., 2007, 2013; Steingroever et al., 2013), which is inconsistent with the basic assumption proposed by Bechara et al. (1994). This finding has been defined as the “prominent deck B (PDB) phenomenon” (Lin et al., 2007), and researchers have inferred that the selection preference is due to a “gain-loss frequency effect”—that is, like good deck D, bad deck B features nine gains and one loss across 10 trials, in terms of net value (Lin et al., 2007; Chiu et al., 2008). The PDB phenomenon has been acknowledged as a critical issue in IGT-related research (Chiu et al., 2018), yet, few studies (Chiu et al., 2012; Steingroever et al., 2013) have fully examined whether it exists in relation to prior IGT-related findings.

Some researchers have attributed a preference for a particular IGT deck with high-frequency gain to cultural differences (Ekhtiari et al., 2009; Bakos et al., 2010). For example, Bakos et al. (2010) found that culture or birth country could partially influence participants’ behavior in the IGT. However, a similar finding regarding high-frequency gain preference in the IGT was also observed in a sample of Iranian participants. Ekhtiari et al. (2009) attributed the demonstration of the phenomenon in this example to the restriction on gambling within Islamic culture and the country’s relatively late development of a bourgeois class.

Chiu et al. (2012) undertook a review of the PDB phenomenon and found that out of 16 studies, 13 (81.25%) obtained results for individual deck selections (i.e., the mean selection number with respect to each deck was presented in the study) that demonstrated the PDB phenomenon. Steingroever et al. (2013) published the results of two reviews related to the IGT: the first examined 17 studies that utilized data regarding selections from four decks (479 normal participants in total); the second review examined 39 groups and the corresponding mean selections from good and bad decks (1,427 normal participants in total). The research team then sent emails requesting the raw data. After receiving responses from seven authors, the researchers collected data from 162 normal participants and analyzed the 8 data sets. Ultimately, both reviews concluded that the normal participants had a preference for low-frequency loss deck B, and the selections persisted until the end of the IGT (Steingroever et al., 2013). The issue of cultural difference, however, was not clearly specified in these review studies.

Following the findings of Chiu et al. (2012) and Steingroever et al. (2013), but in contrast to the observations made by Ekhtiari et al. (2009) and Bakos et al. (2010), we hypothesized that the PDB phenomenon (i.e., a preference of normal participants for the high-frequency gain bad deck B in the IGT) exists cross-culturally. That is, cultural difference may not be a critical factor for interpreting decision-making behavior in the IGT. To test this hypothesis, we reviewed past studies that were identified through a PubMed search of the MEDLINE biomedical database and further integrated the findings of review studies (Chiu et al., 2012; Steingroever et al., 2013) to examine the geographical distribution of IGT-related studies that found individual deck selections in the IGT and plot a global map of the PDB phenomenon.

**METHODS**

**Procedure**

A search for IGT-related studies dating from 1994 to March 31, 2017 was performed on the MEDLINE biomedical database using the PubMed search engine and the keywords “Iowa gambling” and “Bechara card task.” We found 945 articles that featured “Iowa gambling” and 18 articles using “Bechara card task” as keywords. Once we had excluded 12 overlapping IGT-related studies, 951 IGT-related studies were individually reviewed.

**Inclusion and Exclusion Criteria**

We ultimately identified 140 articles that presented deck decisions in the main text, tables, or figures. Regarding the version of the IGT, testing procedure consistencies, and the ages of participants, we excluded 22 studies that used revised versions of the IGT (e.g., the Hungry Donkey task, the inverted IGT, the simple IGT, the net-value IGT, and the Soochow Gambling Task), 9 studies that manipulated testing procedures, 9 studies that did not present the control group data, 9 studies that included participants younger than 17 years of age, 7 studies that presented the results of fewer than 100 trials, 3 studies that only presented representative data, and 2 studies in which the data for deck selection were unclear even though each selection of every participant was presented. Consequently, 79 studies that used the original IGT’s gain-loss structure and presented data for individual deck choices were further analyzed.

Table 1 presents the deck selection data of control participants in 100 IGT trials (namely, over 100 IGT trials were not depicted here) that we extracted from these 79 studies. For studies that presented figures without precise means and standard deviations, we measured and estimated the values based on the scale of the figures.

To increase the integrity of reviewing IGT-related studies, we investigated the studies originally reviewed by Chiu et al. (2012) and Steingroever et al. (2013) that had focused on the issue of high-frequency gain deck preference in the IGT (see Table 2). Six studies were selected after we excluded repeated articles from the database mentioned above. The original selection data of 100 trials in a concurrent IGT condition published in Chiu et al. (2012) were also obtained and included in the present research.
TABLE 1 | Data of normal participants in Iowa Gambling Task (IGT)-related studies from PubMed search, which showed individual deck selections.

| Authors | Sample size (sex) | Mean age (SD) | Source of study | Mean number of card selection | Note |
|---------|-------------------|---------------|----------------|-------------------------------|------|
|         |                   |               |                | Deck A | Deck B | Deck C | Deck D |       |      |
| Petry et al., 1998 | 59 (26F, 33M) | 35 (10) | US | 16.80  | 26.20  | 28.50  | 32.20  | ≈     |
| Petry, 2001 | 21 (21M) | 36.1 (11.5) | US | 15.50  | 24.80  | 27.80  | 32.70  | ≈     |
| North and O’Carroll, 2001 | 20 (4F, 16M) | 30.8 (1.91) | GB | 9.80   | 19.90  | 36.60  | 34.90  | ≈     |
| O’Carroll and Papps, 2003 | 11 (5F, 6M) | 20.0 (3.1) | GB | 15.00  | 26.70  | 20.90  | 35.60  | ≈ Placebo |
| Overman, 2004 | 101 (54F, 47M) | F: 21.1, M: 19.1 | US | 13.00  | 29.25  | 25.50  | 32.25  | % ≈ + Adult Female, Weather Task First Reavis and Overman, 2011 |
|           |                   |               |                | 13.00  | 29.70  | 22.10  | 35.25  | % ≈ + Adult Female, Card Task First Reavis and Overman, 2011 |
|           |                   |               |                | 11.65  | 21.30  | 29.10  | 38.00  | % ≈ + Adult Male, Weather Task First Reavis and Overman, 2011 |
|           |                   |               |                | 13.90  | 25.80  | 32.10  | 28.70  | % ≈ + Adult Male, Card Task First Reavis and Overman, 2011 |
| Shurman et al., 2005 | 10 (5F, 5M) | 32.1 (4.5) | US | 15.70  | 18.50  | 34.00  | 31.80  |       |
| Bark et al., 2005 | 26 (14F, 12M) | 29.81 (9.39) | DE | 22.30  | 29.10  | 24.30  | 24.00  | ≈ +  |
| Rodriguez-Sanchez et al., 2005 | 22 (10F, 12M) | 26.09 (6.49) | ES | 16.91  | 32.05  | 20.50  | 30.55  |       |
| Fernie and Tunney, 2006 | 20 (not reported) | Not reported | GB | 18.80  | 31.60  | 21.05  | 28.55  | Session 1 Hint-Fascimile group |
|           | 20 (not reported) | Not reported | GB | 20.45  | 32.65  | 21.65  | 25.25  | Session 1 No Hint-Fascimile group |
| Northoff et al., 2006 | 14 (7F, 7M) | 28.7 (19–34) | DE | 15.19  | 26.61  | 18.78  | 38.84  | ≈ +  |
| Kester et al., 2006 | 25 (11F, 14 M) | 17.1 (1.8) | US | 20.70  | 25.20  | 25.60  | 28.40  |       |
| Sevy et al., 2007 | 20 (8F, 12M) | 33 (10) | US | 18.00 (5) | 31.00 (8) | 23.00 (6) | 27.00 (6) |       |
| Lee et al., 2007 | 28 (13F, 15 M) | 26.9 (3.6) | KR | 17.60  | 23.60  | 25.50  | 33.10  |       |
| Martino et al., 2007 | 15 (9F, 6M) | 34.96 (10.93) | AR | 15.20  | 26.66  | 21.13  | 37.00  |       |
| Zamarian et al., 2008 | 33 (22F, 11M) | 36.1 (13.7) | AT | 12.50  | 21.40  | 25.60  | 40.40  | Young adults |
|           | 52 (34F, 18M) | 69.3 (7.0) | (6.2) | 15.20  | 26.60  | 22.50  | 35.70  | Old adults |
| Ahn et al., 2008 | 36 (18F, 18M) | 22.0 (18–33) | US | 13.28  | 24.30  | 31.60  | 30.82  | % ≈ +  |
| Viswanath et al., 2009 | 25 (10F, 15 M) | 27.44 (6.40) | IN | 20.68  | 22.84  | 26.04  | 31.24  |       |
| van den Bos et al., 2009 | 10 (10M) | 24.7 (0.5) | NL | 16.80  | 24.00  | 27.80  | 31.40  | Male control subjects |
|           | 12 (12F) | 22.3 (0.4) | NL | 21.30  | 25.20  | 26.40  | 27.10  | Female control subjects |
| Kim et al., 2009 | 55 (26F, 29M) | 28.8 (7.5) | KR | 16.90  | 26.95  | 24.30  | 33.90  | ≈     |
| van Toor et al., 2011 | 31 (15F, 16M) | 36.32 (12.36) | NL | 15.26  | 24.23  | 21.97  | 38.55  |       |
| Martino et al., 2011 | 34 (22F, 12M) | 40.0 (12.9) | AR | 14.70  | 27.10  | 20.40  | 37.80  |       |
| Adida et al., 2011 | 150 (75F, 75M) | 38.8 (10.6) | GB | 17.10  | 24.70  | 25.70  | 32.80  | ≈     |
| Kim et al., 2011 | 21 (21M) | 30.52 (2.98) | KR | 18.05  | 20.19  | 29.67  | 32.10  |       |
| Tchanturia et al., 2012 | 61 (41F, 20M) | 22.2 (5.68) | GB | 17.29  | 25.37  | 25.39  | 31.95  | Female |
|           | 25.45 (7.63) | 12.45  | 27.15  | 29.75  | 30.65  | Male |
| Gansler et al., 2011 | 214 (123F, 91M) | 54.65 (17.44) | US | 15.52  | 28.69  | 20.87  | 34.92  |       |
| Visagan et al., 2012 | 30 (16F, 14M) | 22.2 (3.7) | GB | 11.00  | 28.00  | 23.00  | 33.10  | ≈ +   |

(Continued)
| Authors                          | Sample size (sex) | Mean\_age (SD) | Source of study | Mean number of card selection | Note                                      |
|---------------------------------|-------------------|----------------|----------------|-------------------------------|-------------------------------------------|
|                                 |                   |                |                | Deck A | Deck B | Deck C | Deck D |                                      |
| Matsuzawa et al., 2015          | 50 (17F, 33M)     | 31.9 (7.8)     | JP             | 15.94  | 29.18  | 20.46  | 34.43  | Same subjects as Gansler et al., 2011 but exclude Connecticut subjects. |
| Seeley et al., 2014             | 92 (76F, 16M)     | Not reported   | CA             | 18.16  | 34.88  | 17.76  | 31.26  | % ≈ +                                    |
| Hong et al., 2015               | 30 (6F, 24M)      | 29.1 (7.6)     | CN             | 19.70  | 21.60  | 31.40  | 29.00  | % ≈ +                                    |
| Matsuura et al., 2015           | 40 (30F, 10M)     | 18.90          | US             | 22.30  | 29.85  |             |            |
| Seeley et al., 2014             | 45 (6F, 39M)      | 24.7 (3.1)     | DE             | 13.92  | 33.59  | 21.71  | 30.79  | % ≈ +                                    |
| Alameda-Bailen et al., 2012     | 27 (5F, 22M)      | 35 (10.44)     | AU             | 16.64  | 34.88  | 17.76  | 31.26  | % ≈ +                                    |
| Gescheidt et al., 2012          | 49.95 (9.03)      |                 | CZ             | 20.50  | 24.40  | 25.30  | 29.80  | % ≈ +                                    |
| Horstmann et al., 2012          | 119 (66F, 53M)    | 25.2 (4.9)     | DE             | 13.92  | 33.59  | 21.71  | 30.79  | % ≈ +                                    |
| Alameda-Bailen, 2011            | 17–29 y/o: 664    | 18.90          | US             | 22.30  | 29.85  |             |            |
| Carvalho et al., 2012           | 40 (22F, 18M)     | 25.50 (4.70)   | BR             | 14.75  | 30.90  | 20.88  | 34.28  | Young adults                             |
| Steingroever et al., 2013       | 82 (2F, 80M)      | 25.56 (4.86)   | NL             | 15.00  | 35.00  | 20.00  | 30.00  | % ≈ +                                    |
| Worthy et al., 2013             | 41 (30F, 11M)     | 21.29 (18–29)  | US             | 14.78  | 34.24  | 25.36  | 25.72  | % ≈ +                                    |
| van den Bos et al., 2013        | 213 (140F, 73M)   | Not reported   | NL             | 18.70  | 26.90  | 27.00  | 27.20  | % ≈ Female (the reconstruct data)        |
| Miller et al., 2013             | 77 (77F)          | 17–25          | US             | 14.10  | 31.84  | 20.99  | 33.06  | % ≈ Male (the reconstruct data)          |
| Le Berre et al., 2014           | 45 (7F, 38M)      | 44.76 (7.78)   | FR             | 20.31  | 20.22  | 30.69  | 28.78  | % ≈ +                                    |
| Kim et al., 2012                | 33 (17F, 16M)     | 27.8 (3.0)     | KR             | 17.10  | 24.40  | 27.50  | 30.80  | % ≈ +                                    |
| Penolazzi et al., 2013          | 84 (44F, 40M)     | 26.47 (7.14)   | IT             | 14.60  | 30.80  | 22.30  | 33.90  | % ≈ +                                    |
| Lin et al., 2013                | 72 (37F, 35M)     | Not reported   | TW             | 18.69  | 30.53  | 22.99  | 27.79  | % ≈ +                                    |
| Vassileva et al., 2013          | 12 (12F)          | 33.5 (8.5)     | US             | 16.90  | 33.10  | 22.50  | 27.70  | % ≈ HIV-seronegative/no crack cocaine and/or heroin use history |
| Kloeters et al., 2013           | 28 (12F, 16M)     | 64.2 (4.4)     | AU             | 12.30  | 28.20  | 20.30  | 39.20  | % ≈ +                                    |
| Buelow and Suhr, 2014           | 70 (48F, 22M)     | 18.94 (1.21)   | US             | 18.16  | 29.22  | 22.19  | 30.44  | % ≈ +                                    |
| Lavin et al., 2014              | 10 (5F, 5M)       | 23.4 (2.4)     | CL             | 21.30  | 34.80  | 20.00  | 23.90  | % ≈ +                                    |
| Beitz et al., 2014              | 17–29 y/o: 664    | 18.90          | US             | 14.90  | 25.30  | 25.80  | 35.10  | % ≈ +                                    |
| Cote et al., 2014               | 55 (27F, 28M)     | 33.4 (17.4)    | BR             | 17.00  | 25.80  | 23.00  | 36.50  | % ≈ +                                    |
| Wolk et al., 2014               | 17 (8F, 9M)       | 36.53 (12.10)  | DE             | 16.44  | 35.25  | 20.31  | 28.00  | % ≈ +                                    |
| Cardoso et al., 2014            | 18 (14F, 4M)      | 59.26 (10.25)  | BR             | 16.00  | 22.61  | 25.61  | 36.65  | % ≈ +                                    |
| LeGris et al., 2014             | 41 (41F)          | 31.2 (9.0)     | CA             | 13.40  | 26.05  | 23.34  | 37.20  | % ≈ +                                    |
| Lee et al., 2014                | 52 (26F, 26M)     | 21.39 (3.64)   | TW             | 15.28  | 31.98  | 25.54  | 27.20  | % ≈ +                                    |
| Alameda-Bailen et al., 2014     | 63 (26F, 37M)     | 25.11 (6.01)   | ES             | 15.60  | 23.80  | 30.50  | 30.50  | % ≈ +                                    |
| Hong et al., 2015               | 30 (6F, 24M)      | 29.1 (7.6)     | CN             | 19.70  | 21.60  | 31.40  | 29.00  | % ≈ +                                    |
| Seeley et al., 2014             | 92 (76F, 16M)     | Not reported   | CA             | 18.15  | 33.10  | 21.10  | 29.05  | % ≈ + Session 1                          |
| Matsuzawa et al., 2015          | 50 (17F, 33M)     | 31.9 (7.8)     | JP             | 20.90  | 29.10  | 26.10  | 24.40  | % ≈ +                                    |
| Evans and Hampson, 2015         | 93 (48F, 45M)     | 19.69 (17–28)  | CA             | 15.60  | 31.10  | 21.80  | 34.20  | % ≈ +Male                                 |
|                                 |                   |                |                |       |       |       |       | % ≈ +Female                               |

(Continued)
TABLE 1 | Continued

| Authors          | Sample size (sex) | Mean$_{age}$ (SD) | Source of study | Mean number of card selection | Note      |
|------------------|-------------------|-------------------|----------------|-----------------------------|-----------|
|                  |                   |                   |                | Deck A | Deck B | Deck C | Deck D |
| Hori et al., 2014| 51 (26F, 25M)     | 36.7 (9.9)        | JP             | 17.70  | 26.00  | 30.70  | 25.20  | ±         |
| Ma et al., 2015  | 24 (24M)          | 21.7 (1.8)        | CN             | 19.70  | 31.50  | 24.70  | 24.10  | ±         |
| Bull et al., 2015| 50 (30F, 20M)     | 21.44 (3.79)      | NZ             | 16.10  | 21.30  | 30.80  | 31.80  | ±         |
| Brown et al., 2015| 43 (17F, 26M)    | 41.1 (11.8)       | US             | 15.00  | 29.40  | 24.60  | 31.70  | ±         |
| Zhang et al., 2015c| 88 (41F, 47M)    | 19.17 (1.29)      | CN             | 25.00  | 30.40  | 21.40  | 23.90  | ±         |
| Wright et al., 2017| 36 (22F, 65M)    | 23.5 (18–28)      | IL             | 12.50  | 26.30  | 25.00  | 34.40  | Study 2   |
| Lin et al., 2016 | 145 (43F, 102M)  | 18.6 (0.97)       | TW             | 17.39  | 32.47  | 19.60  | 25.96  | % ±       |
| Pedersen et al., 2017| 38 (16F, 22M)  | 40 (13.8)         | DE             | 19.10  | 30.70  | 19.60  | 30.60  | ±         |
| Li et al., 2016  | 145 (43F, 102M)  | 18.6 (0.97)       | TW             | 17.39  | 32.47  | 24.73  | 25.41  | ±         |
| Yechiam et al., 2016| 130 (65F, 65M) | 23.5 (18–28)      | IL             | 12.50  | 26.30  | 26.30  | 34.40  | Study 2   |
| Visser-Keizer et al., 2016| 59 (22F, 37M) | 43.50 (1.90)      | NL             | 14.90  | 29.30  | 25.20  | 30.60  | ±         |
| Wright et al., 2017| 36 (Not reported) | Not reported       | GB             | 17.50  | 23.80  | 25.60  | 30.90  | ±         |
| Jollans et al., 2017| 20 (9F, 11M)    | 24.9 (4.8)        | GB             | 18.82  | 34.49  | 21.10  | 25.96  | % ±       |

Note: AR, Argentina; AT, Austria; AU, Australia; BR, Brazil; CA, Canada; CH, Chile; CN, China; CZ, Czechia; DE, Germany; ES, Spain; FR, France; GB, United Kingdom; IL, Israel; IN, India; IT, Italy; JP, Japan; KR, South Korea; NL, Netherlands; NZ, New Zealand; TW, Taiwan; and US, United States of America. The abbreviation codes were based on the “ISO 3166-1 alpha-2” (https://en.wikipedia.org/wiki/List_of_ISO_3166_country_codes).

Note: The first step of data redrawn from the figure is to measure the length (mm) of a single unit of the Y-axis. Accordingly, the second step is to convert each data point in the figure to how many card selections. Notably, there are some potential small errors (e.g., the length of the first unit is not totally equal to that of the second unit of Y-axis in the same figure) in the procedure of estimation, so we have to make a note here; some of the estimated data sets were summed into 100 and some are not.

±Data were transcribed from figures.
± + Data of average deck selection in blocks were transcribed and summed.
% ± + Data of average deck selection percentage in blocks were calculated and summed.
% ± + Data of average deck selection percentage in blocks were transcribed, calculated, and summed.

Note: Without special signs above: numerical deck selection data were obtained from original studies.

In total, there were seven studies sourced from Chiu et al. (2012) and Steingroever et al. (2013).

Study Selection and Data Extraction

Two authors (W-KL and C-JL) independently retrieved the studies that presented individual deck selections (i.e., in the main text, tables, or figures). They independently reviewed each study to extract the data and measured the average selection numbers (i.e., based on the scale of the figures). Any disagreement with respect to the process of study selection or data extraction was resolved through consensus via repeated measurements and discussion. All average numbers of choice obtained through measurement by two researchers were controlled under the difference ≤1 selection approach.
TABLE 2 | Data of normal participants in IGT-related studies included in Chiu et al. (2012) and Steingroever et al. (2013).

| Authors            | Sample size (sex) | MeanAge (SD) | Source of study | Mean number of card selection | Note                           |
|--------------------|-------------------|--------------|-----------------|-------------------------------|--------------------------------|
|                    |                   |              |                 | Deck A | Deck B | Deck C | Deck D |                     |
| Bechara et al., 1994 | 44 (21F, 23M)     | Not reported | US              | 14.00  | 16.00  | 35.00  | 35.00  | ≈                   |
| Wilder et al., 1988 | 30 (18F, 12M)     | 30.2 (9.7)   | US              | 20.20  | 26.80  | 7.00   | 24.10  | 28.90 ≈ |
| Tomb et al., 2002  | 10 (5F, 5M)       | Not reported | US              | 15.00  | 19.00  | 34.00  | 32.00  | ≈                   |
| Ritter et al., 2004 | 15 (15M)          | 47.1 (10.2)  | US              | 18.00  | 25.00  | 24.00  | 33.00  | ≈                   |
| Caroselli et al., 2008 | 141 (73F, 68M) | 21.7 (4.6)  | US              | 22.00  | 35.00  | 20.00  | 23.00  | ≈                   |
| Fum et al., 2008   | Not reported      | Not reported | IT              | 14.87  | 32.84  | 17.09  | 35.19  | Experiment 1 standard condition |
| Chiu et al., 2012  | 24 (12F, 12M)     | Not reported | TW              | 18.13  | 31.50  | 25.71  | 24.67  | 100 trials selection data obtained from authors |

Note. IT, Italy; TW, Taiwan; and US, United States of America.
≈Data were transcribed from tables of the review studies.

Data Analysis
Data analysis was performed on a total of 86 studies, 79 of which were retrieved from the MEDLINE biomedical database and 7 from the 2 review studies noted above (Chiu et al., 2012; Steingroever et al., 2013). Notably, each experimental condition performed by normal participants in the 86 studies was considered as a single data set, even though there may in fact have been 2 (Fernie and Tunney, 2006; Zamarian et al., 2008; van den Bos et al., 2009, 2013; Carvalho et al., 2012; Tchanturia et al., 2012; Beitz et al., 2014; Evans and Hampson, 2015; Huang et al., 2015; Okdie et al., 2016; Piper et al., 2016), 3 (Zhang et al., 2015c), or 4 experimental conditions (Overman, 2004) in the original study (experimental conditions are marked in the note of Table 1). In total, 102 data sets obtained from 86 studies were subsequently analyzed.

To verify whether a "gain-stay loss-randomize" decision strategy was demonstrated in the different data sources, we conducted a decks-by-groups repeated measures analysis of variance (ANOVA) using IBM SPSS Statistics (version 22) and analyzed individual deck selection data. To visualize whether the PDB phenomenon is cross-cultural, all studies that presented the 86 studies—specifically, every experimental condition performed by normal participants in these 86 studies originated from 16 regions (Argentina, Australia, Brazil, Canada, Chile, China, Germany, Israel, Italy, Japan, Netherlands, South Korea, Spain, Taiwan, United Kingdom, and the United States—and van den Bos et al. (2009; see Table 1 and Figure 1). Although unclassifiable in the global map (see gray circles in Figure 1), the data sets from the four studies were still included in the following analysis.

RESULTS
The repeated measures ANOVA showed that the interaction effect of groups (studies retrieved from the database search and review studies) and decks was nonsignificant, \( F(2.377, 237.73) = 0.445, p = 0.676\) (Greenhouse–Geisser correction). The main effect of the decks was significant, \( F(2.377, 237.73) = 39.141, p < 0.001, \eta^2 = 0.281\), but that of the groups was not, \( F(1, 100) = 0.123, p = 0.726\). In short, the results indicated no difference between the data obtained from the MEDLINE database and the review studies (Chiu et al., 2012; Steingroever et al., 2013).

As there was no difference between the two data sources, we combined the data obtained from the two sources (86 studies in total) and further conducted a repeated measures ANOVA to test for differences between decks. The results showed a significant difference with respect to the selections of individual decks, \( F(2.379, 240.293) = 171.702, p < 0.001, \) and \( \eta^2 = 0.63\) (Greenhouse–Geisser correction). The selection of deck B was significantly higher than that of decks A, \( p < 0.001, \) and C, \( p < 0.001.\) Moreover, the selection of deck C was higher than that of deck A, and the selection of deck D was higher than those of all other decks, \( ps < 0.001.\) These results suggest that the PDB phenomenon was common in the reviewed studies (Figure 2).

Combining the results of the studies from the MEDLINE database and the review studies, we found that 67.44% (58 of 86) featured a selection of the disadvantageous deck B ≥ 25 times, and this preference corresponded to our definition of the PDB phenomenon (detailed above). As shown in Figure 1, the normal participants in these 58 studies originated from 16 regions of North America, South America, Europe, Oceania, and Asia: specifically, Argentina, Australia, Brazil, Canada, Chile, China, Germany, Israel, Italy, Japan, Netherlands, South Korea, Spain, Taiwan, United Kingdom, and the United States.
FIGURE 1 | The Iowa Gambling Task (IGT) global map. The figure illustrates the geographical distribution of IGT-related studies that showed individual deck selections. Red circles indicate studies demonstrating the PDB phenomenon, green circles indicate studies that support the original IGT assumptions, and gray circles indicate studies that were unclassifiable. AR, Argentina; AT, Austria; AU, Australia; BR, Brazil; CA, Canada; CL, Chile; CN, China; CZ, Czechia; DE, Germany; ES, Spain; FR, France; GB, United Kingdom; IN, India; IT, Italy; JP, Japan; KR, South Korea; NL, Netherlands; NZ, New Zealand; TW, Taiwan; and US, United States of America. Adapted from “Robinson projection, national borders, areas grouped” (https://en.wikipedia.org/wiki/Wikipedia:Blank_maps#/media/File:BlankMap-World.svg) in the public domain.

FIGURE 2 | Mean number of card selections in 86 IGT-related studies. The figure was produced by averaging the numbers of the four decks chosen across the 86 IGT-related studies. Selections of deck B were relatively higher than those of decks A and C, demonstrating that the PDB phenomenon was present. This finding is consistent with those obtained in a growing number of other IGT-related researches.
DISCUSSION

Most IGT-related studies have used the calculation \((C + D) - (A + B)\) to define decision-making performance. Correspondingly, the basic assumption of the IGT (Bechara et al., 1994, 1997) posited that normal (control group) participants could perform advantageously and make rational decisions guided by implicit emotion, in contrast to participants who were unable to access an emotional system due to a vmPFC lesion. However, the present article found that in 67.44% (58 out of 86) of the IGT-related studies that showed individual deck selection data, a preference for the disadvantageous deck B was observed. The participants in these 58 studies originated from 16 different areas across North America, South America, Europe, Asia, and Oceania. Therefore, we infer that the PDB phenomenon in the IGT is cross-cultural.

Individual and Cultural Issues in the IGT

A prior critical review article (Dunn et al., 2006) reiterated Bechara and Damasio’s (2002) finding that about 20% of normal participants performed poorly in the IGT. In fact, Bechara and Damasio (2002) showed that 37% of normal (control group) participants performed within the range of vmPFC patients, referring to the criterion of the net score \((C + D) - (A + B) < 10\). The present research showed that in more than 60% of sample studies, normal participants consistently favored the disadvantageous deck B. This PDB phenomenon is evidently different from the results obtained by Bechara and Damasio (2002).

Previous IGT-related studies have attributed participants’ preference for decks with a high-frequency gain (decks B and D) to cultural issues. For example, Bakos et al. (2010) postulated that a preference for deck B only existed in certain cultures and further investigated decision-making differences between Brazilians and Americans. In their study, 17% of the Brazilian participants in an IGT were categorized as “normal decision makers,” compared to the 60% of American participants who were categorized as normal, according to the measure \((C + D) - (A + B) > 18\), a criterion proposed by Denburg et al. (2005). These results suggested that Americans perform better than Brazilians in the IGT; Bakos et al. (2010) posited that the difference might relate to capitalism in the United States making the daily lives of Americans much more reliant on their ability to manage financial issues compared to Brazilians. However, the study did not clarify whether a preference for decks with a high-frequency gain existed in both Americans and Brazilians.

Similar to our study, Ekhtiari et al. (2009) performed an analysis of individual decks and found that Iranian participants favored the high-frequency gain decks B and D. The researchers attributed the phenomenon to two possible causes: (1) the limitations on gambling under Islamic law meant that Iranian participants were unclear about or lacking gambling concepts, which further affected their decision-making performance in the IGT according to frequency-based valuations; and (2) the late development of a bourgeois class in Iran, and therefore of concepts such as land ownership and work ownership, meant that the country’s workers lacked long-term decision-making experience (Ekhtiari et al., 2009). In contrast to the cultural difference perspective, we suggested a cross-cultural preference for high-frequency gain decks B and D in the IGT. This is supported by our confirmation that the phenomenon exists in 16 areas across North America, South America, Europe, Asia, and Oceania.

However, although our sample of studies showed that the PDB phenomenon existed cross-culturally, the finding was limited by the lack of analysis regarding cultural factors. Future studies could further analyze the performance of normal participants under different cultural factors (e.g., Western or Eastern cultural contexts) and examine whether the PDB phenomenon exists universally.

Methodological Issue in Iowa Gambling Task-Related Studies

Furthermore, of the 951 IGT-related studies originally sourced through the MEDLINE database, only 140 showed individual deck data, and most of the remaining 811 studies used the calculation \((C + D) - (A + B)\) to differentiate the performances of clinical versus control participants. It is possible that the scoring method may have obscured the existence of the PDB phenomenon in control participants (Chiu and Lin, 2007; Lin et al., 2007, 2013; Steingroever et al., 2013) and further neglect differences between the preferences of clinical versus control participants for individual decks. Consequently, researchers may be missing opportunities to observe differences regarding more specific decision-making patterns.

In the present research, we further analyzed the 86 studies that featured individual deck data according to the criterion \((C + D) - (A + B) < 10\), as used by Bechara and Damasio (2002). According to this analysis, 45.35% (39 out of 86) of the studies showed that normal participants performed within the range of vmPFC patients (see Supplementary Table 1). Additionally, even more studies (67.44%, 58 out of 86) demonstrated that the normal participants consistently preferred the disadvantageous deck B. These findings significantly challenge the basic assumption of the IGT and suggest that evidence of PDB phenomenon is obscured by the use of the measure \((C + D) - (A + B)\). We therefore recommend that future studies should investigate and compare the individual deck selections of clinical participants based on the consistent performance of the control participants.

A New Raising Perspective: Gain–Loss Frequency

The preference for bad deck B shown by normal participants in the IGT was first demonstrated by Wilder et al. (1998), and the phenomenon has since been documented by other researchers (Toplak et al., 2005; Fernie and Tunney, 2006; Lin et al., 2007, 2013; Takano et al., 2010; Steingroever et al., 2013). Prior studies have defined participants’ preferences for bad deck B and good deck D in the IGT as the “gain-loss frequency effect” (Lin et al., 2007; Chiu et al., 2008), as the preference is associated with the high-frequency gain structure (i.e., nine gains, one loss) of both bad deck B and good deck D. The observed preference also implies that, under uncertainty conditions, control participants...
will use a “gain-stay loss-randomize” strategy, meaning that the probability of choosing the same deck will increase when participants face continuous gains, whereas the choice will be randomized when they face loss (Chiu et al., 2008; Worthy et al., 2013b; Lin et al., 2016). This strategy has been employed in recent IGT-related model studies (Worthy et al., 2013b; Lin et al., 2016).

Notably, the findings of our research depart from the original IGT study by Bechara et al. (1994) who proposed that normal (control group) participants would form a “somatic marker” (Damasio, 1994) when experiencing the gains and losses in the IGT and gradually develop a sensitivity to the long-term outcome—that is, preferring advantageous decks C and D and avoiding disadvantageous decks A and B. However, other studies (Wilder et al., 1998; Toplak et al., 2005; Fernie and Tunney, 2006; Lin et al., 2007, 2013; Takano et al., 2010; Steingroever et al., 2013) and the current findings have failed to replicate their results obtained in relation to normal participants. The present study also supports the argument that the PDB phenomenon should be evaluated in contemporary IGT-related studies given the apparent inconsistency with respect to the original IGT hypothesis (Chiu et al., 2018). In other words, the hypothesis proposed in the original IGT study should be carefully reconsidered and revised.

CONCLUSION

The present review found that in over 60% of IGT studies, most normal (control group) participants favored the disadvantageous deck B and consistently applied a gain–loss frequency strategy. These findings are incongruent with the original inference made by Bechara and Damasio (2002), Ekhtiari et al. (2009), and Bakos et al. (2010) that the poor performance of normal participants was due to individual and cultural differences. The PDB phenomenon and the influence of gain–loss frequency in the IGT might be obscured by the analysis and presentation methodology being principally based on the net score measure (C + D) − (A + B). Considering the present integrative review and analysis of 958 studies, we conclude that gain–loss frequency could be a cross-cultural factor during decision making under dynamic-uncertain conditions.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/Supplementary Material.

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AUTHOR CONTRIBUTIONS

Y-CC initiated this research topic and C-HL focused on refining the issue. Y-CC and C-HL constructed the research strategy and developed its main structure. Y-CC, C-HL, and W-KL undertook the literature review and defined the research database. Y-CC, C-HL, and W-KL developed the idea of mapping the geographical distribution of IGT-related studies for this manuscript, and W-KL created the corresponding artwork. W-KL completed the first round of the literature data collection, defined the categorization criteria and data administration, and drafted the preliminary manuscript. C-JL completed the second round of literature data collection, redefined the categorization criteria, and finalized the data re-categorization, as well as providing some interpretation. L-HL created the initial preliminary uncompleted draft in Chinese. W-KL, C-JL, C-HL, and Y-CC undertook several rounds of discussion, and all authors finalized and approved the manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.537219/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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