Games with imperfect information
- Games discussed so far (EFGs) are of perfect information
- Every player has perfect knowledge about all the developments in the game until that round
- Limited practical use – several games have states that are unknown to certain agents – e.g., card games
- Not possible to represent simultaneous move games using EFGs

<table>
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<tr>
<th></th>
<th>Agri</th>
<th>War</th>
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<tbody>
<tr>
<td>Agri</td>
<td>5,5</td>
<td>0,6</td>
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<tr>
<td>War</td>
<td>6,0</td>
<td>1,1</td>
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</tbody>
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[Diagram of the Neighbouring Kingdom's Dilemma]

Player 2 does NOT know which node/history the game is in
- These indistinguishable histories form an information set for player 2
- More general representation than PIEFGs, since information sets can be singleton

IIEFGs are not unique for a given simultaneous move game
- The kingdom's dilemma can also be represented this way with (non-singleton) information set for 1.
An IIEFG is a tuple \( \langle N, A, H, X, P, (u_i)_{i \in N}, (I_i)_{i \in N} \rangle \)
where \( \langle N, A, H, X, P, (u_i)_{i \in N} \rangle \) is a PIEFG
for every \( i \in N \), \( I_i := (I_{i}^{1}, I_{i}^{2}, \ldots, I_{i}^{k_i}) \) is a partition of
\( \{ h \in H \setminus Z : P(h) = i \} \) with the property that \( X(h) = X(h') \) and
\( P(h) = P(h') = i \), whenever \( \exists j \) s.t. \( h, h' \in I_i^j \).

\( I_i^j \)'s \ are \ called \ the \ information \ sets \ of \ player \ i, \ I_i \ is \ the \ collection
of \ information \ sets \ of \ i. \)

At an information set, player and her available actions are same.

That player is uncertain about which history in the information set is reached.

Some differences with the PIEFG:

- Since actions at an information set are identical, \( X \) can be defined
  over \( I_i^j \)'s, i.e., \( X(h) = X(h') = X(I_i^j), \forall h, h' \in I_i^j \).

- Strategies can also be defined over information sets.

Strategy set of player \( i \in N \) is defined as the cartesian product of the
actions available to \( i \) at her information sets, i.e.,
\[
S_i = \bigotimes_{i \in I_i} X(I_i^j) = \prod_{j=1}^{k_i} X(I_i^j)
\]

With IIEFGs, NFGs can be represented using EFGs, although not very
succinct. Representations are appropriate for certain kind of games.

However, IIEFG is a richer representation than both NFG and PIEFG.