Ko

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Abstract

For the first time, ko-intersection and its types, ko, ko-stone, ko-string, and the necessary fundamental terms are defined in general for all positions so that **not** all stones in all positions are ko-stones. Examples are given.

Preface

Ko is one of the key strategic concepts. Therefore it is extremely important to know what it is, i.e., to be able to distinguish what is a ko from what is not a ko. This paper gives the answer.

Identifying basic-kos is very easy - identifying kos related to cycles of more than 2 moves is very, and sometimes extremely, difficult. For that reason, traditional Go theory could define the basic-kos currently on the board as kos but had no systematic understanding of kos in general. The rarity of kos related to cycles with 4 or more plays (one of them occurs only about once every ca. 5,000th to 10,000th game) contributed to the delay. Now the answer comes from the view of mathematical abstraction.

Go players having difficulty with the abstract definitions of cycle-set, left-part, (answer-)strategy and (answer-)compatible might still try to get an intuitive understanding: Instead of ordinary ko and game end rules, the "default restriction rules" are used. They prohibit single stone suicide, use the fixed-ko-rule, allow a basic-ko recapture after intervening passes and otherwise end a sequence after a cycle ending at the position at the start of a sequence or end a sequence by 3 successive passes. The fixed-ko-rule allows a recreated position but then prohibits the same next play, i.e., a cycle may occur but not recur. - Ko is defined via its ko-intersections. In informal words, a local-ko-intersection requires a player to force a cycle while the opponent prevents the player from improving the local area on the related cycles' intersections. A global-ko-intersection requires a player to force a cycle while the opponent prevents the player's win when considering the whole board score and the komi.

Does the reader wonder why the rules used for the definitions differ from ordinary rules? The default restriction rules are used to *define* "ko". Some set of ordinary rules is used to *regulate practical playing.* By distinguishing the two purposes, the definition works regardless of which ordinary rules are used.

A ko-intersection can be of one, two or three of the types basic-, local- or global-ko-intersection. Some intersections are only local-ko-intersections. Some others are only global-ko-intersections.

What does the abstract's condition "so that not all stones in all positions are ko-stones" mean? It is trivial but for practical purposes also meaningless to define ko so that all intersections of the board and in all positions are ko-intersections. Rather than expecting the players to cooperate, the definitions rely on the concept "force".

Fundamentals

Presuppositions and Basic Definitions I

- Defined elsewhere are in particular: play, move, current-position, basic-ko, (situational) cycle.

- Given the basic Go rules, either allowed or prohibited suicide, and a scoring method.
- The *history-bans* is the set of ko bans prior to the start of analysis.
- The *start-position* is the current-position or a particular position.

Default Restriction Rules

- The *1-play-rule* prohibits a cycle consisting of 1 play.
- The *basic-ko-rule* prohibits immediate recapture in a basic-ko.
- The *fixed-ko-rule* prohibits a play to leave position A and create position B if an earlier play left position A and created position B.
- The *3-pass-rule* ends the game in case of 3 successive passes.
- The *cycle-end-rule* ends the game when a) a situational cycle starting at the start-position occurs and b) a recapture in a basic-ko after exactly 2 successive, intervening passes does not occur.
- The *default restriction rules* are the 1-play-rule, the basic-ko-rule, the fixed-ko-rule, the 3-pass-rule, the cycle-end-rule.

Basic Definitions II

- A *move-sequence* is a sequence of moves under the default restriction rules, starting from the start-position, letting the players alternate moves and ending due to the cycle-end-rule or the 3-pass-rule.
- A *left-part* of a move-sequence is either the whole move-sequence or a part that consists of one or more than one successive moves of it and starts with its first move.
- A player's *strategy* is a set of one or more than one left-parts of move-sequences so that each left-part starts with a move of his, each left-part ends with a move of his, there are not two left-parts so that they without their last move are equal, and the aforementioned conditions are not true for the set together with any left-part not in the set.
- For a player, an *answer-strategy* of the opponent is a set of one or more than one left-parts of move-sequences so that each left-part starts with a move of the player, each left-part ends with a move of the opponent, there are not two left-parts so that they without their last move are equal, and the aforementioned conditions are not true for the set together with any left-part not in the set.
- A move-sequence is *compatible* with a strategy of a player if each left-part that is of the move-sequence and ends with a move of the player is in the strategy.
- For a player, a move-sequence is *answer-compatible* with an answer-strategy of the opponent if each left-part that is of the move-sequence and ends with a move of the opponent is in the answer-strategy.

Applied Definitions

- A player *can force* something if there is at least one strategy of his so that each compatible move-sequence fulfils that something.
- A player *does force* something if he uses a strategy of his so that each compatible move-sequence fulfils that something.

- *prevent* something is force to fulfil not the something.
- A player *can answer-force* A if the opponent moving second uses an answer-strategy that - regardless of the player's first move - does force B and if there is at least one strategy of the player so that each move-sequence that is compatible with the player's strategy and answer-compatible with the opponent's answer-strategy fulfils A.
- For a move-sequence, there is the first moving player's *local-area-improvement* on exactly a set of intersections if its area score before the move-sequence is smaller than its area score after the move-sequence.
- A cycle's *cycle-set* is the set of all the intersections of the cycle's plays.

Types of Ko Intersections

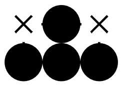
- A ***basic***-*ko-intersection* is an intersection of a basic-ko.
- Under default restriction rules without history-bans, a ***local***-*ko-intersection* is an intersection for which a set of cycles exists so that
    - each of the cycles starts from the start-position,
    - each of the cycles has at least one play creating the current-position,
    - the intersection belongs to each of the cycles' cycle-sets, and
    - a player can answer-force one of the cycles by moving first in it if the opponent moving second does prevent local-area-improvement of the player on the cycle-set.
- Given the komi, the history-bans and the moving player and using the default restriction rules, a ***global***-*ko-intersection* is an intersection for which a set of cycles exists so that
    - each of the cycles starts from the current-position,
    - each of the cycles has at least one play creating the current-position,
    - the intersection belongs to each of the cycles' cycle-sets, and
    - the player can answer-force one of the cycles by moving first in it if the opponent moving second does prevent the player's win.

Ko

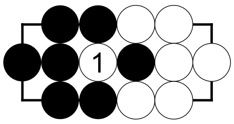
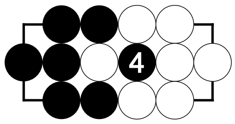
- A *ko-intersection* is an intersection that is at least one of basic-ko-intersection, local-ko-intersection, global-ko-intersection.
- A *ko* is a ko-intersection and, recursively, any adjacent ko-intersection.
- A *ko-stone* is a stone on a ko-intersection.
- A *ko-string* is a ko-stone's string.

Reasons for the Non-obvious Conditions

1-play-rule

	Without the 1-play-rule and under rules allowing suicide, each of the marked intersections would be a local-ko-intersection because Black could prevent White's local-area-improvement and White could force a 1-move-cycle by suiciding on either intersection.

Fixed-ko-rule

 2 pass, 3 pass.	 5 pass, 6 pass. Continuation. The moves 1 to 6 could recur forever. The move-sequence would not end.	Suppose there would be no fixed-ko-rule. The cycle-end-rule does not end the game when a recapture in a basic-ko after exactly 2 successive, intervening passes occurs. The 3-pass-rule does not end the game after only 2 successive passes. The basic-ko-rule prohibits 5 to recapture 4 immediately but does not prohibit 7 to recapture 4. Therefore the fixed-ko-rule is also needed to ensure an end of the game. Here it prohibits 7 to play at 1.

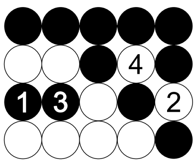
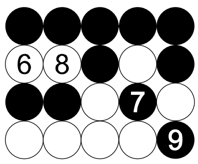
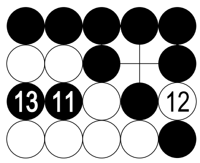
Allowing instead of Prohibiting Cycles

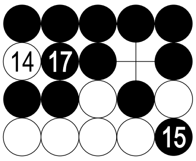
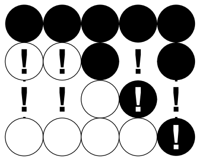
The fixed-ko-rule together with the basic-ko-rule allow cycles. Instead the positional-superko-rule would prohibit cycles. The definitions of local- and global-ko-intersection rely on the existence of cycles. Therefore cycles have to be allowed for the default restriction rules used for these definitions. That cycles are allowed for the purpose of identifying kos on the definition level does not imply at all that ordinary ko and game end rules would be required to allow cycles - rather they have the freedom of choice whether to allow cycles. This coexistence of definition versus ordinary rules can be seen, e.g., also for basic-ko in some real world rulesets: They define a [basic-]ko by "immediate recapture would recreate the position / initial shape" and then add the stricter basic-ko-rule, which prohibits immediate recapture. This paper uses the same kind of approach but in general for all kos instead of only basic-kos.

3-pass-rule

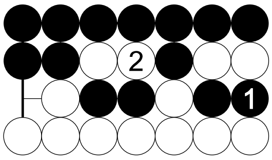
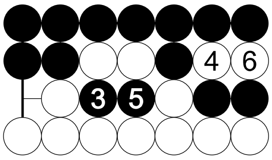
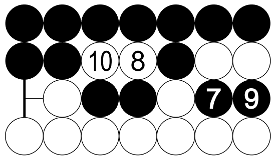
The 3-pass-rule instead of a 2-pass-rule enables usage of passes as ko threats.

Cycle-end-rule

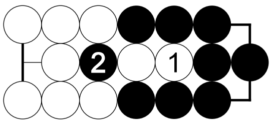
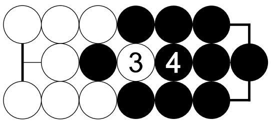
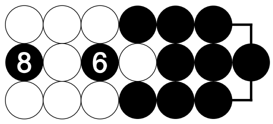
 5 pass.	 10 pass. Continuation. Without cycle-end-rule, 10 would not end the game.	 Continuation. From the position before 11, Black has not played on the intersection of 11 yet. Therefore 11 is not prohibited under the fixed-ko-rule.

 16 pass, 18 pass, 19 pass, 20 pass. (continuation)	White may not play 14 at the intersection of 4 because this would be prohibited by the fixed-ko-rule.	 Since White could not prevent Black's local-area-improvement on the 8 interesting intersections, none of them would be a local-ko-intersection. Hence, to let them be local-ko-intersections, also the cycle-end-rule is needed.

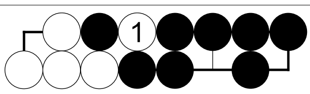
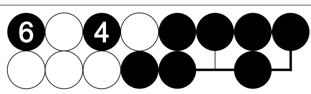
Start-position Condition in Cycle-end-rule

	 (continuation)	 Continuation. 3 to 10 is a situational that does not end at the start-position. If the cycle-end-rule ended the game nevertheless, Black could not answer-force a cycle that creates the start-position before move 1.

Situational Condition in Cycle-end-rule

 Before 1, it is White's turn. After 3, it is Black's turn. Therefore the cycle from 1 to 3 is not situational. If Black 4 passed, then the cycle from 1 to 4 would be situational.	 5 pass. Continuation. Without the situational condition in the cycle-end-rule, already 3 would invoke the game end and Black would not get a chance to remove the white stones.	 7 pass, 9 pass, 10 pass, 11 pass. Continuation. The removal must be allowed to model also those ordinary rulesets that allow it.

Basic-ko Recapture Condition in Cycle-end-rule

 2 pass, 3 pass. The removal of all the white stones must be allowed to model also those ordinary rulesets that allow it.	 5 pass, 7 pass, 8 pass, 9 pass. (continuation)	Although the moves 1 to 4 are a situational cycle, move 4 does not end the game by the cycle-end-rule because of its exception "a recapture in a basic-ko after exactly 2 successive, intervening passes".

Both Local- And Global-ko-intersection

Although global-ko-intersections that are neither basic- nor local-ko-intersections are rare (only two shape classes are known and only one game has been reported so far), they do exist. What exists must be explained regardless of rarity.

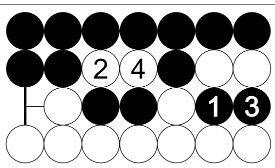
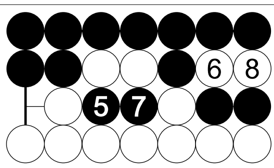
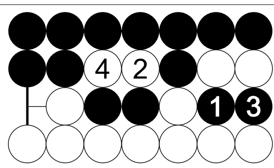
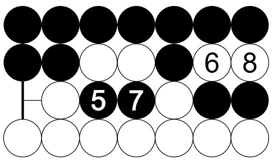
Everybody calls a shape like, e.g., a round-robin-ko a ko shape. This is so regardless of whether currently perfect-play should make plays in it or whether possibly some plays elsewhere on the board (like such capturing huge strings or closing huge territories) are more urgent. Similarly everybody calls an endgame ko a ko regardless of whether it exists on the board already since the opening or middle game. Usage of the type local-ko-intersection makes it always possible to identify the round-robin-ko's intersections as ko-intersections - even when they are not global-ko-intersections.

Instead of wondering why two newly defined types of ko-intersections are necessary, the reader should be astonished that *only* two suffice. That just two new types describe all known ko shapes shows how well these types have been chosen. A careless theory would use more types - a good theory uses as few types as necessary.

History-bans

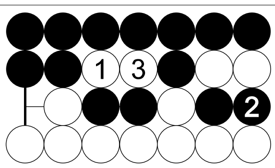
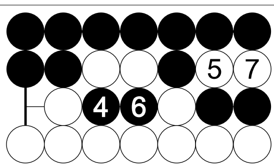
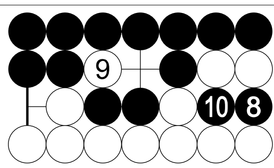
Local-ko-intersection ignores history-bans because a) it is a local concept and b) either player might be the one who can answer-force a cycle by moving first in it. Global-ko-intersection does not need history-bans but works well with or without them. Therefore it is defined in the more general way. Thereby a current-position of a game can be studied in two ways: by considering or ignoring the history-bans.

Set of Cycles

 Variation 1	 (continuation)	 Variation 2
 (continuation)	If White prevents Black's local-area-improvement, then Black can answer-force a cycle of the set of cycles including those in Variations 1+2. Black cannot answer-force a particular cycle though. E.g., if Black tried to answer-force the cycle of Variation 1, then White might choose to play as in Variation 2 to prevent Black's local-area-improvement nevertheless. This shows that in general it does not suffice to consider only one cycle but one has to consider a set of cycles.	

Start-position for Local-ko-intersection

There are two reasons why it does not always suffice to start from the current-position: 1) The player might already have as much local-area on the cycle-set as he can get (e.g., he might have the entire cycle-set as his area). Then it is trivial for the opponent to prevent the player's local-area-improvement. 2) It might be possible to answer-force some cycle but not necessarily a cycle of that a play creates the current-position, as is shown in the example:

 If Black wants to prevent White's local-area-improvement, he has to allow White answer-forcing some cycle.	 (continuation)	 Continuation. Black does not need to play 8 at 10 though. Therefore White cannot force creation of the current-position. The cycle from 2 to 10 does not create it. If local-ko-intersection relied on the current-position as the start-position, the 8 intersections would not be local-ko-intersections.

Relation

The cycles of a set of cycles are related to each other: They start from the same position. Each of the cycles is related to the current-position: Each must create it. Each of the cycles is related to the intersection tested as a ko-intersection: It belongs to each of the cycles' cycle-sets.

Specific Conditions for Global-ko-intersection

Global-ko-intersection refers to the komi, the moving player and the current-position as the start-position because it shall be applicable to the current state of a game in progress.

Core Conditions

"a player can answer-force one of the cycles [...] if the opponent [...] does prevent local-area-improvement of the player on the cycle-set" and "the player can answer-force one of the cycles [...] if the opponent [...] does prevent the player's win" are the core conditions of the definitions of local- or global-ko-intersection, respectively. Reference to cycle does surprise nobody. Only using "a player can force a cycle" would not work because a) the opponent might always pass in case of an attempted non-suicide cycle and b) the opponent might make simple intervening plays in case of an attempted sucide cycle. Forcing a cycle works only as an answer (therefore answer-force) to a duty for the opponent with that he is being so busy forcing it that meanwhile the player gets his chance to construct a cycle. What remains to be told is the opponent's duty: either to prevent local-area-improvement of the player on the cycle-set or to prevent the player's win for local- or global-ko-intersection, respectively.

Remarks

- The author proved that each string in each position can recur in a cycle if there are no ko rules and the players cooperate. Things are very different and much more difficult under some given restriction rules if one player tries to force while the opponent tries to prevent a cycle.
- The greatest hurdles before discovery of the ko-related definitions were: 1) definition of force, which was solved, e.g., in the Japanese 2003 Rules, 2) finding and defining well the default restriction rules, 3) understanding that practically useful definitions of ko-related terms depend on force, 4) understanding that it is easier to approach a definition of ko-intersection first regardless of whether an intersection is occupied, 5) identifying the exact conditions of local-/global-ko-intersection. Altogether the author needed 13.5 years, all his knowledge on ko and rules and some of his earlier inventions to overcome all these hurdles. E.g., when he had invented the fixed-ko-rule in 1997, it had been pure theory at that time; in the meantime it has become applied theory. Hence in retrospect it is not surprising that a general definition of the seemingly very basic concept ko has escaped all players and researchers for a very long time.
- Previous versions of the definitions worked for all but one or a few shape classes. The current version appears to work for all known shape classes. It could happen though that a new shape class is discovered for that the current version would not assign the expected characterization. This possibility lets the current theory of definitions be a model rather than necessarily the final theory. The behaviour of kos has to be understood yet better before one can be sure to have found the final theory.
- During the alternating-sequence, it is dynamic whether an intersection is a ko-intersection and of which types it is.
- Under the definitions, a single stone suicide does not define a ko-intersection because the

default restriction rules prohibit 1-play-cycles. For other purposes, one might provide another type of ko-intersections to include the intersections of single stone suicides.

- In the definitions of local-/global-ko-intersection, "does prevent" is supposed to imply "can prevent".
- In some shapes like, e.g., round-robin-ko or molasses ko, a player cannot answer-force a particular cycle but can answer-force some cycle of a set of cycles. Therefore the definitions need to rely on set of cycles. A set might contain one cycle only though.
- Since, in the definitions, the player can answer-force one of the cycles, then the set of cycles cannot be empty whenever there shall be some local-/global-ko-intersection. Therefore it is not necessary to specify a not empty condition explicitly.
- The condition "each of the cycles has at least one play creating the current-position" relates the cycles to the current-position and the condition "the intersection belongs to each of the cycles' cycle-sets" relates the potential ko-intersection to the cycles.
- Besides prohibited single stone suicide (1-play-cycle), some assumptions are made for long cycles. a) Long cycles also through basic-kos become interesting at all due to some restriction for playing in a basic-ko: the basic-ko-rule. Besides basic-ko recapture might be allowed or prohibited after intervening passes. From traditional and ambiguous rulesets (like the Japanese 1989 Rules), it is unclear whether this was intended. Other rulesets (like the Ing 1991 Rules) allow passes to serve as ko threats. As a consequence of inconclusive tradition, research must allow both cases: with or without passes as ko threats. Therefore the less restrictive option of allowing passes to serve as ko threats is specified in the cycle-end-rule and thereby used for the default restriction rules and their usage of a general definition of ko. This does not mean though that each defined ko would be possible under all restriction rules stricter than the default restriction rules. b) To enable passes as ko threats, the default restriction rules are sufficiently relaxed: the cycle-end-rule allows pass as a ko threat for a basic-ko and three (not just two) successive passes end the game; a basic-ko capture in a ko, two passes and then a recapture in the same basic-ko constitute a situational cycle with exactly 2 plays but still allow the meaning of pass as a ko threat because the game does not end yet. c) Not just an assumption but even a requirement is to reject cycles created by the players' cooperation for its own sake. The default restriction rules combined with the force-dependent concepts avoid it that otherwise all strings in all positions would be ko strings. d) With respect to one cycle, the fixed-ko-rule, which is included in the default restriction rules, is the most liberal. - As a consequence of the above mutually balancing assumptions and their realization in the definitions, each intersection that someone has seen as belonging to a ko is defined as a ko-intersection while each intersection that nobody has seen as belonging to a ko is defined not to be a ko-intersection. People with a more restrictive perception of ko can use ko / restriction rules that are more restrictive than the default restriction rules and can develop their strategy more closely to perfect-play so that they will make fewer strategic mistakes by making a cycle's move at inappropriate timing. They should understand though that the definitions here are related to the most liberal rather than the strictest restriction rules and are allowing both strategically inactive and perfect-play kos.
- 1) When currently in a game position fighting a ko is premature, it does not have global-ko-intersections. To identify such kos nevertheless, one needs local-ko-intersections. 2) The existence of global-ko-intersection Example 4 proves that the type global-ko-intersection is needed because, on the interesting intersections, it does not have local-ko-intersections.
- A local-ko-intersection is called "local" because only the local-area-improvement is considered. A global-ko-intersection is called "global" because the whole board's score and the komi are considered.

- The default restriction rules are used to define "ko" but here they are not used to define perfect-play under given rules.
- Traditional Go theory has considered ko as something on the board. Nevertheless, one might be tempted to think of ko as something being equivalent to a cycle with plays on the ko's intersections. This kind of definition would have several problems though: a) In general, a ko has to be defined by a set of cycles rather than always only one particular cycle. b) To achieve unequivocality for a set of cycles, an additional condition of set-maximality would be needed: The other conditions are not true for the union of the set of cycles and a cycle not in the set. c) Such a maximal set of cycles would define all the ko's intersections as the union of all the cycle-sets of the set's cycles. d) Somehow all up to two sets given due to the two types local-/global-ko-intersection need to be taken into consideration. e) The resulting concept would not be so much ko-like any longer but more Ing style ko-position-like. - There may be reasons for related theoretical studies. For practical purposes though, ko as defined here (giving a connected set of intersections) is very useful. If one really wants to refer to the cycles, this can be done using the suggested definitions for the types of ko-intersection. It would be superfluous though to always refer to cycles if all one wants to consider is the location of a ko on the board.

Future Research

- Research in ko and its characteristics should be improved to decide whether the current definitions are a temporary model or the final theory for a definition of ko.
- New ko shape classes, if any, should be discovered and checked against the current definitions.
- Big kos not consisting of only basic-kos should be classified into types quite like basic-kos are classified.
- More advanced terms like ko-threat should be defined.
- A suicide play of a cycle-set's cycle defining a ko-intersection should be found if some exists.
- Ko-position should be defined in the sense of Ing Ko Rules or the New Ko Rules. Reference to ko-coupling should be replaced by reference to set of cycles like in the definitions of local-/global-ko-intersection. Instead of "ko-position", a better name should be chosen because ko-position is used also in a different meaning of "a position with at least one ko in it".
- Hidden kos should be studied in greater detail.
- All intersections that are not ko-intersections should be classified.

Examples of Ko-intersection

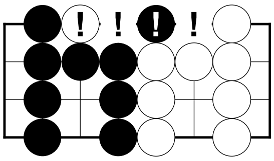
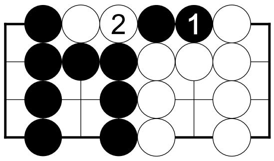
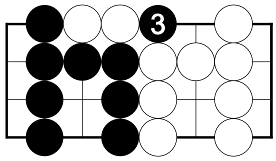
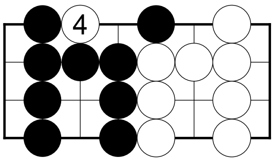
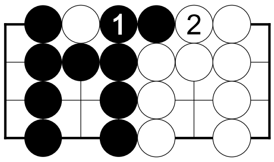
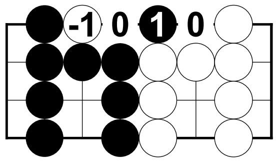
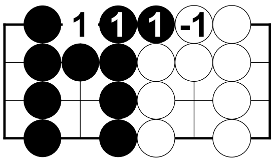
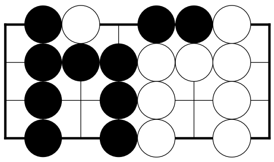
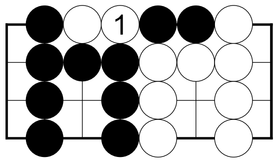
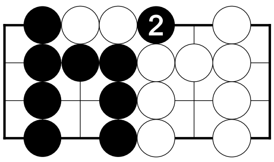
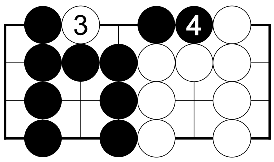
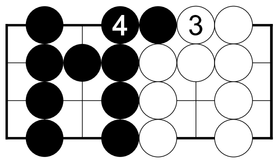
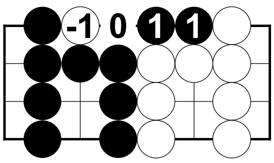
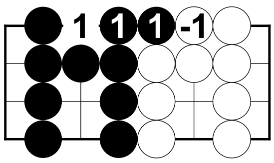
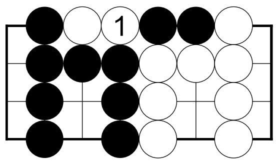
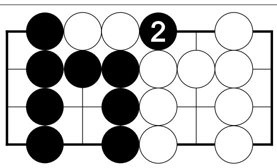
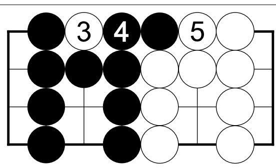
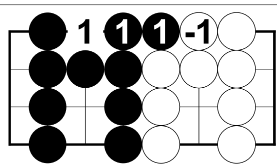
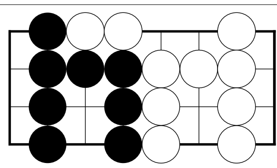
Unless specified otherwise, the examples presume area scoring. Obvious rests of move-sequences are sometimes not shown. For most examples, only one type of ko-intersection is verified; ko-intersections might also be of other types.

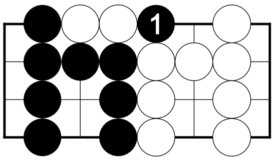
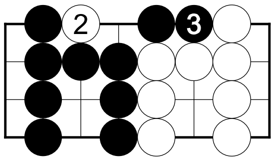
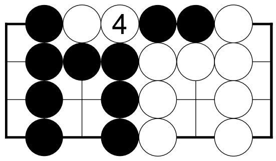
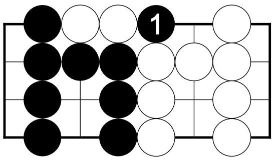
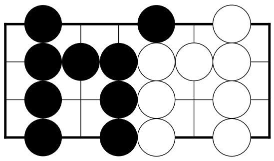
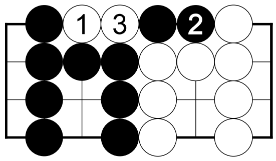
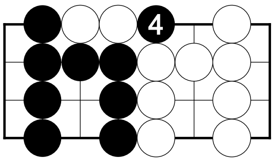
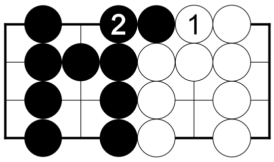
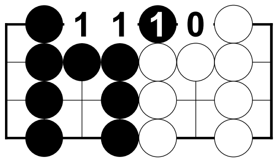
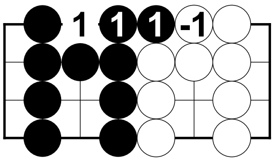
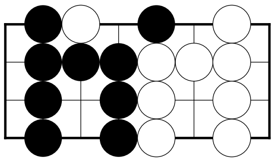
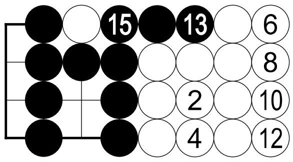
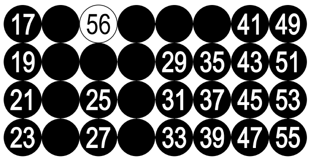
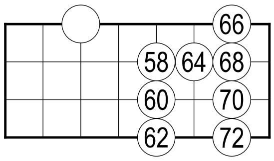
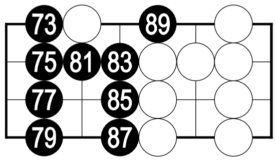
Apart from a) bigger hell kos and b) a cycle with 7 plays, the examples show all known shape classes of long cycle shapes consisting not only of basic-kos. Multiples do not create new problems for local-ko-intersections because it suffices to study move-sequences restricted to each shape separately. The author is grateful for new discoveries.

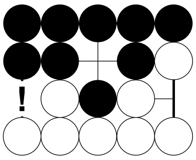
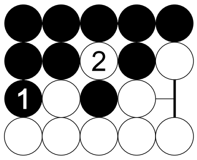
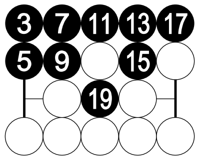
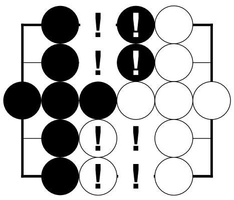
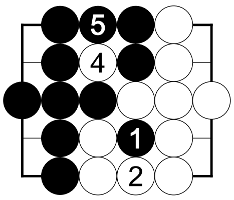
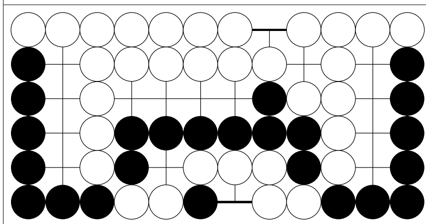
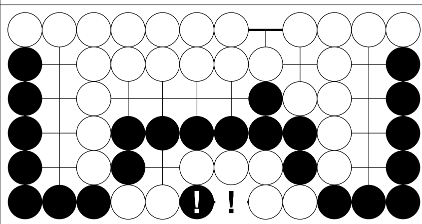
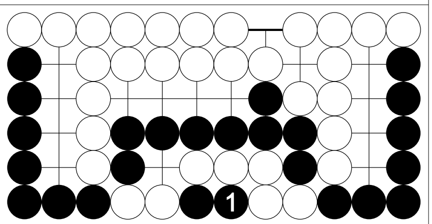
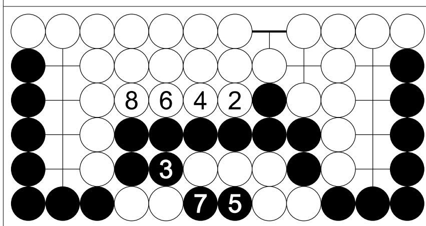
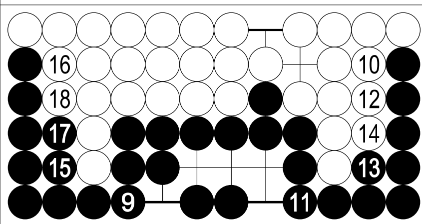
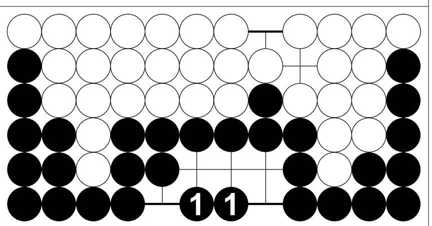
The *local-area* of a cycle-set is the area score on only its intersections in the position's context.

Counter-examples

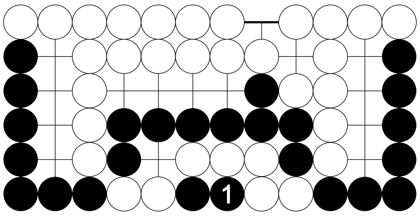
Counter-examples are as important as positive examples. Since there is no general classification of all non-ko-intersections yet, any counter-example that would be classified as a positive example by the definition of ko-intersection would let this definition be a failure.

 **Counter-example 1:** In particular, none of the marked intersections is a local-ko-intersection.	 Cycle 1: a cycle. The start-position is the current-position. Play 4 creates the current-position.	 (continuation)
 (continuation)	 Variation 1.1. The opponent White cannot prevent the player Black's local-area-improvement.	 Before Variation 1.1, the local-area is 0.
 After Variation 1.1, the local-area is 2.	 Cycle 2: start-position. Play 3 creates the current-position.	
 (continuation)	 (continuation)	 Variation 2.1 (continuation from first moves of Cycle 2).
 Before Variation 2.1, the local-area is 1.	 After Variation 2.1, the local-area is 2.	 Variation 2.2.
 (continuation)	 6 pass, 7 pass, 8 pass. (continuation)	 After Variation 2.2, the local-area is 2.
With sequences like Cycle 2, Variation 2.1 and Variation 2.2, the opponent Black does prevent the player White's local-area-improvement.	Black chooses 4 in Variation 2.2 rather than 4 in Cycle 2. The player White cannot answer-force the cycle in Cycle 2.	 Cycle 3: start-position. Play 2 creates the current-position.

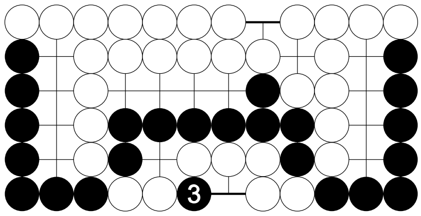
	 (continuation)	 (continuation)
 Variation 3.1: By answering 1, the opponent White cannot prevent the player Black's local-area-improvement.	 Cycle 4: start-position of a cycle. Play 1 creates the current-position.	
 (continuation)	 3 pass, 4 pass, 5 pass. Variation 4.1: The opponent Black cannot prevent the player White's local-area-improvement.	 Before Variation 4.1, the local-area is 3.
 After Variation 4.1, the local-area is 2.	 Cycle 5: start-position of a cycle. Play 89 creates the current-position.	 1 pass, 3 pass, 5 pass, 7 pass, 9 pass, 11 pass, 14 pass, 16 pass.
 18 pass, 20 pass, 22 pass, 24 pass, 26 pass, 28 pass, 30 pass, 32 pass, 34 pass, 36 pass, 38 pass, 40 pass, 42 pass, 44 pass, 46 pass, 48 pass, 50 pass, 52 pass, 54 pass. (continuation)	 57 pass, 59 pass, 61 pass, 63 pass, 65 pass, 67 pass, 69 pass, 71 pass. (continuation)	 74 pass, 76 pass, 78 pass, 80 pass, 82 pass, 84 pass, 86 pass, 88 pass. (continuation)

Variation 5.1: See Variation 1.1. The opponent White cannot prevent the player Black's local-area-improvement.	For all super-long cycles, application of the definition of local-ko-intersection is similarly trivial.	Summary: A cycle fitting all the requirements of the definition of local-ko-intersection does not exist. Therefore none of the marked intersections is a local-ko-intersection.
 **Counter-example 2:** In particular, the marked intersection is not a local-ko-intersection.	 A cycle including a play on the marked intersection must be long. Such makes it essentielly impossible for a player to answer-force.	 4 pass, 6 pass, 8 pass, 10 pass, 12 pass, 14 pass, 16 pass, 18 pass.
 **Counter-example 3:** Even none of the marked intersections is a ko-intersection.	 3 pass, 6 pass, 7 pass, 8 pass.	A cycle cannot be answer-forced by either player (here: Black). - Since it is easy for the players to cooperate even in perfect-play and create a round-robin-ko-like cycle, this is a very important example for showing Ing's failure when describing ko stones naively as stones that can be captured cyclically or repeatedly. Nevertheless, Ing deserves the honour of having motivated the author of this text to search for a careful definition.
 **Counter-example 4:** Suicide allowed, komi 0. The position's topic was described by Denis Feldman but maybe it had been invented before.	 Even none of the marked intersections is a **local-ko-intersection**. Local-area = 1.	 Variation 1 for the current-position as the start-position.
 (continuation)	 19 pass, 20 pass, 21 pass. (continuation)	 Local-area = 2.

If Black chooses move 3 (and Black, for the purpose of the definition, can choose it), then White cannot prevent Black's local-area-improvement. Therefore the local-ko-intersection definition's condition "if the opponent (White) moving second does prevent local-area-improvement of the player on the cycle-set" cannot be fulfilled for the two intersections as the supposed cycle-set. Hence neither of these intersections is a local-ko-intersection.

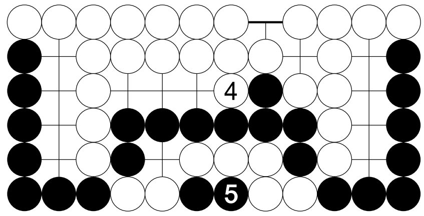


Variation 2 for the current-position as the start-position.

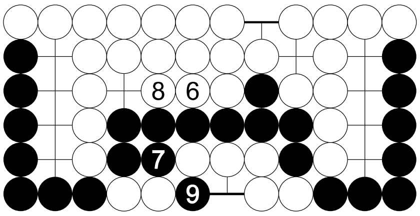


② pass.

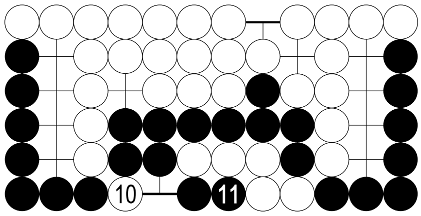
Continuation. The moves 1 to 3 are not a situational cycle. Therefore the cycle-end-rule does not end the game just after 3.



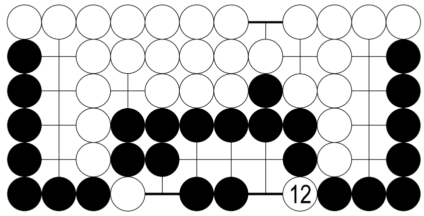
(continuation)



(continuation)

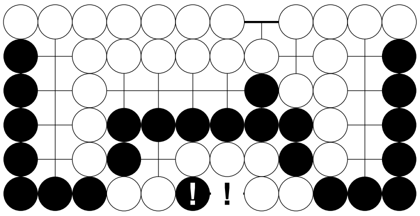


(continuation)

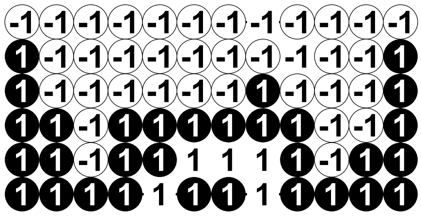


(continuation)

Move 2 is shown for the purpose of showing the cycle from 1 to 3. However, move 3 is a strategic mistake for the purpose of the definition's condition "if the opponent (White) moving second does prevent local-area-improvement of the player on the cycle-set". Black can choose better than move 3 in Variation 2 by replacing it with move 3 of Variation 1. Although White tries differently with move 2, the local-area emerging after some more moves following move 12 of Variation 2 is White's dream only. In reality, the local-area will end up like in Variation 1. For the definition's purpose, we may as well assume move 2 of Variation 2 to be dominated by move 2 of Variation 1.

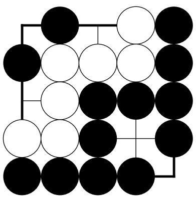


Black to move. Even none of the marked intersections is a **global-ko-intersection**.

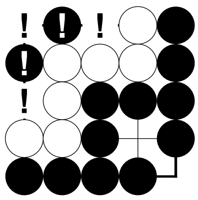


Score after Variation 1 = 36 - 36 - 0 = 0.

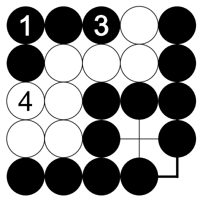
Although White does prevent Black's win, Black cannot answer-force a cycle. Therefore neither of the marked intersections is a global-ko-intersection. (Note: Although suiciding 2 stones is the easiest possible suicide task, White is not forced to pass in between the plays of these stones. It is surprisingly difficult to construct a ko with suicide. Trivial territory shapes don't work, either.)



Counter-example 5

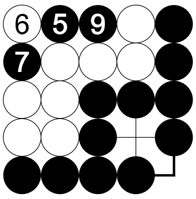


Even none of the marked intersections is a **local**-ko-intersection.



② pass.

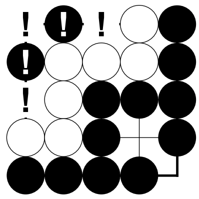
Variation 1



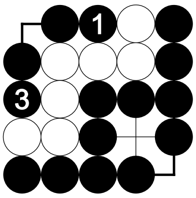
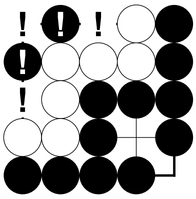
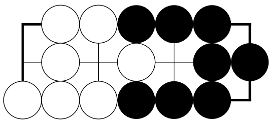
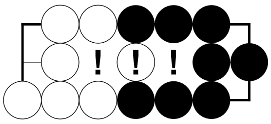
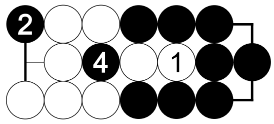
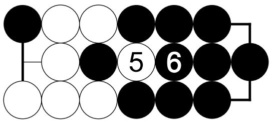
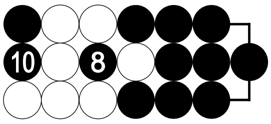
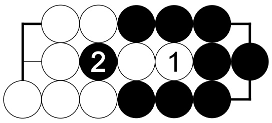
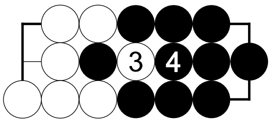
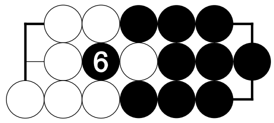
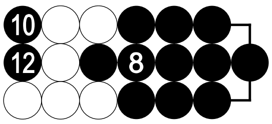
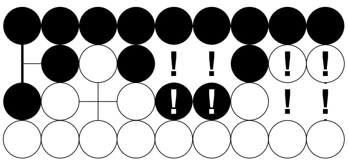
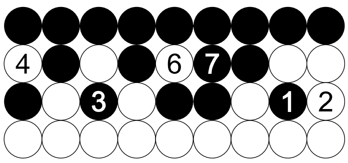
⑧ pass,
⑩ pass,
⓫ pass,
⑫ pass.

(continuation)

In Variation 1, White cannot prevent Black's local-area-improvement from 3 to 5. Therefore in particular none of the marked intersections is a local-ko-intersection. The sending-2-returning-1 ko cycles are immaterial for the purpose of the application of the definition's condition "if the opponent (White) does prevent [...]". Besides the definition does not care for the hidden bent-4-in-the-corner kos; it only looks for kos currently on the board.



Black to move. If the komi is 25, then even none of the marked intersections is a **global**-ko-intersection. - After Variation 1, the score is 0.

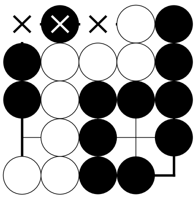
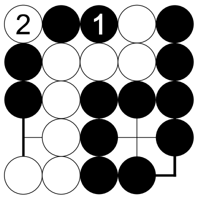
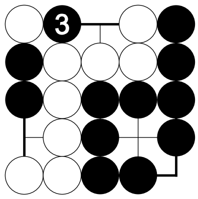
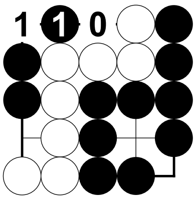
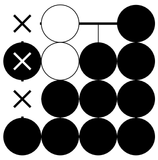
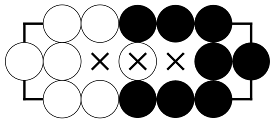
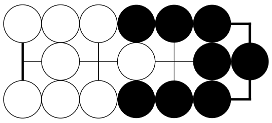
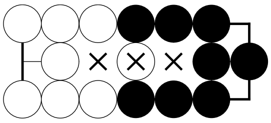
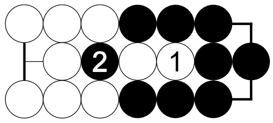
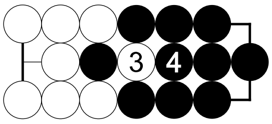
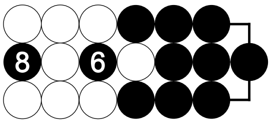
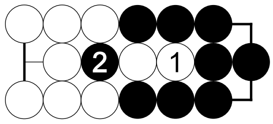
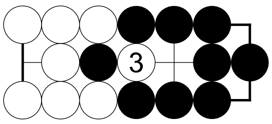
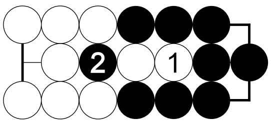
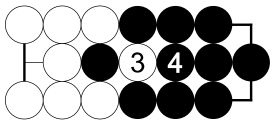
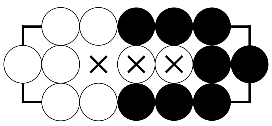
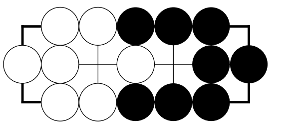
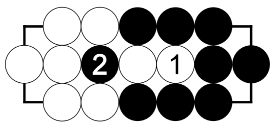
 ② pass, ④ pass, ❺ pass, ⑥ pass. Variation 2	After Variation 2, the score is 0. With Variations 1+2, White prevents Black's win. Black cannot answer-force a cycle though because, in Variation 2, White does not need to capture. Therefore even none of the intersections is a global-ko-intersection.	 Black to move. If the komi is 24.5, then even none of the marked intersections is a **global**-ko-intersection. - After Variation 1, the score is 0.5. White cannot prevent Black's win.
 **Counter-example 6**	 Even none of the marked intersections is a **local**-ko-intersection.	 ③ pass. Variation 1
 ⑦ pass. (continuation)	 ⑨ pass, ⑪ pass, ⓬ pass, ⑬ pass. (continuation)	If Black does prevent White's local-area-improvement, White cannot answer-force a cycle that creates the current-position because, in Variation 1, Black can choose to approach the white liberties differently.
 Variation 2	 ⑤ pass. Continuation. 3 does not complete a situational cycle. Therefore the cycle-end-rule does not end the game.	 ⑦ pass. (continuation)
 ⑨ pass, ⑪ pass, ⑬ pass, ⓮ pass, ⑮ pass. (continuation)	To prevent White's local-area-improvement under default restriction rules, Black could also choose Variation 2. However, for the purpose of the definition's condition "the player (White) can answer-force one of the cycles", Black does not choose Variation 2. If one wanted to perceive the shape as a Dead Ko, then one should introduce another type of ko-intersection with all of these conditions: a) It is not a global-ko-intersection. b) A "related" cycle exists so that during it the players use perfect-play. c) A player can choose his perfect-play between a cycle as in (b) or not creating a "related" cycle.	
 **Counter-example 7:** None of the marked intesections is a local-ko-intersection.	 ❺ pass, ⑧ pass, ❾ pass, ⑩ pass.	White prevents Black's local-area-improvement. Black cannot answer-force a cycle that creates the current-position.

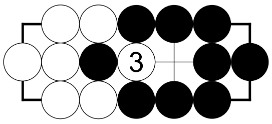
Basic-ko-intersection

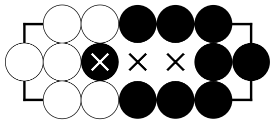
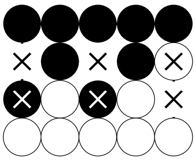
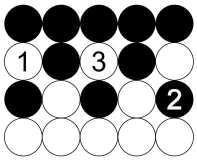
Each basic-ko currently on the board as such serves as an example, regardless of being a single ko or part of a multiple or multi-stage ko etc. Usually hidden kos do not have any basic-ko-intersection.

Local-ko-intersection

The definition of local-ko-intersection does not care whether a ko is worth fighting in a global context now, later or never.

<table>
<tr>
<td>
Example 1: Each of the marked intersections is a local-ko-intersection.</td>
<td>
Although White does prevent Black's local-area-improvement, Black can answer-force a cycle on the marked intersections. Play 3 creates the current-position.</td>
<td>
④ pass.
Continuation. 4 invokes the cycle-end-rule.</td>
</tr>
<tr>
<td>
Before or after the cycle (before move 1 or after move 3), the local-area is 2.</td>
<td>
Example 2: like Example 1.</td>
<td>
Example 3: like Example 1 with swapped colours.</td>
</tr>
<tr>
<td>
Example 4</td>
<td>
Each of the marked intersections is a local-ko-intersection.</td>
<td>
Variation 1</td>
</tr>
<tr>
<td>
⑤ pass.
Continuation. 3 does not complete a situational cycle. Therefore the cycle-end-rule does not end the game. This is the most prominent example why the rule has the "situational" condition in it.</td>
<td>
⑦ pass, ⑨ pass,
❿ pass, ⑪ pass.
Continuation.</td>
<td>
Variation 2</td>
</tr>
<tr>
<td>
❹ pass.
Continuation. 4 invokes the cycle-end-rule.</td>
<td>
Variation 3</td>
<td>
⑤ pass, ❻ pass,
⑦ pass.
(continuation)</td>
</tr>
<tr>
<td colspan="3">While Black, using any of the Variations 1-3, prevents White's local-area-improvement, White answer-forces the cycle move 1 to 3, which occurs in each of these variations. Move 3 creates the current-position. Therefore each of the marked intersections is a local-ko-intersection.</td>
</tr>
<tr>
<td>
Example 5: Each of the marked intersections is a local-ko-intersection.</td>
<td>
The cycle starts from this start-position.</td>
<td>
Play 1 creates the current-position.</td>
</tr>
</table>

<table>
<tr>
<td>

Continuation. It suffices if Black passes next because that invokes the cycle-end-rule.</td>
<td>Although Black does prevent White's local-area-improvement, White can answer-force a cycle on the marked intersections.</td>
<td>
Example 6: Like Example 5: See the cycle and cycle start-position there. Play 2 creates the current-position.</td>
</tr>
<tr>
<td colspan="3">From the positions of Examples 5+6, neither player can answer-force a cycle. This is immaterial for the definition of local-ko-intersection though; it does not require the cycle to start from the current-position. Rather it requires in particular some play of the cycle to create the current-position.</td>
</tr>
<tr>
<td>
Example 7: Each of the marked intersections is a local-ko-intersection.</td>
<td>
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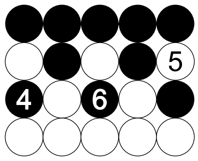
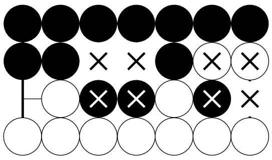
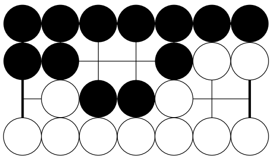
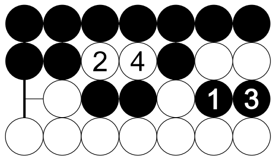
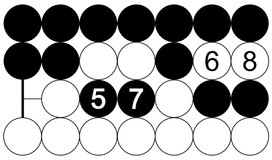
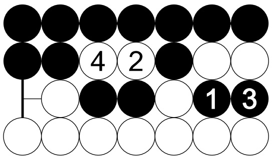
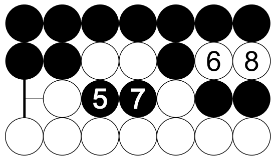
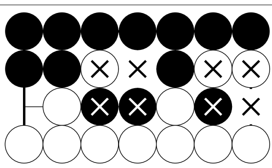
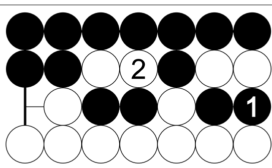
<td>

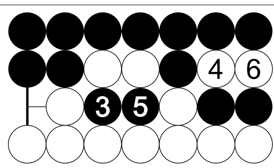
Continuation. 6 invokes the cycle-end-rule.</td>
</tr>
<tr>
<td colspan="3">The opponent Black does prevent the player White's local-area-improvement. White can answer-force a cycle like the one from 1 to 6. Therefore each of the marked intersections is a local-ko-intersection.</td>
</tr>
<tr>
<td>
Example 8: Each of the marked intersections is a local-ko-intersection.</td>
<td>
Start-position of the cycles in Variations 1+2. Play 1 creates the current-position.</td>
<td>

Variation 1.</td>
</tr>
<tr>
<td>

Continuation. 8 invokes the cycle-end-rule.</td>
<td>

Variation 2.</td>
<td>

Continuation. 8 invokes the cycle-end-rule.</td>
</tr>
<tr>
<td colspan="3">For each of the cycles of Variations 1 or 2, the player Black is without local-area-improvement. This means that the opponent White does prevent Black's local-area-improvement. Very other White choices can be dismissed as not fulfilling this. Black does not create a so called stable seki because the definition asks him to answer-force a cycle. Black 1 is necessary to fulfil the condition to recreate the current-position; Black may not refuse to do so; it is outside Black's choice because it is simply a matter of existence of this cycle. Black cannot answer-force a particular cycle - Black can answer-force one of the cycles of Variations 1 or 2 or other variations with similar cycles. Since Black can answer-force one of these cycles, each of the marked intersections is a local-ko-intersection.</td>
</tr>
<tr>
<td>
Example 9: Each of the marked intersections is a local-ko-intersection.</td>
<td>

Variation 1. White does not choose this variation because he would not prevent Black's local-area-improvement.</td>
<td>

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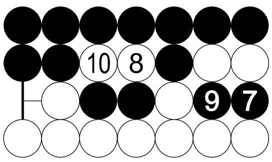
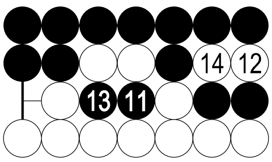
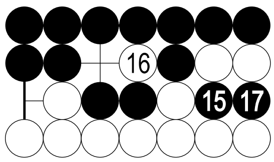
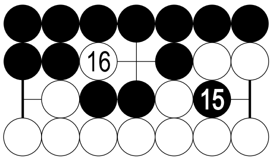
<td>

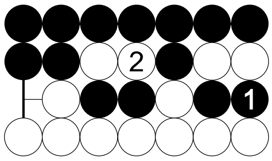
(continuation)</td>
<td>

(continuation)</td>
<td>

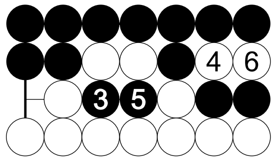
Continuation. The fixed-ko-rule prohibits White 18 at 10.</td>
</tr>
</table>



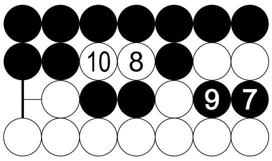
Variation 2. Start like Variation 1. Move 16 completes a situational cycle that creates the current-position.



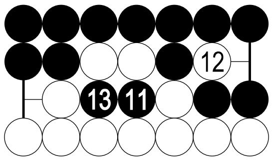
Variation 3. White does not choose this variation because he would not prevent Black's local-area-improvement.



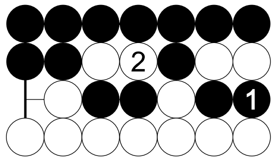
(continuation)



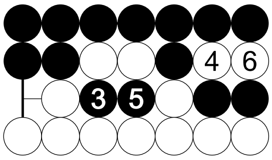
(continuation)



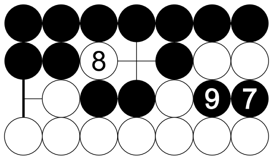
Continuation. The fixed-ko-rule prohibits White 14 at 6.



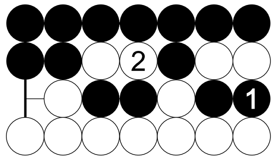
Variation 4. White does not choose this variation because he would not prevent Black's local-area-improvement.



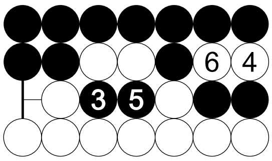
(continuation)



Continuation. The fixed-ko-rule prohibits White 10 at 2.



Variation 5. White does not choose this variation because he would not prevent Black's local-area-improvement.



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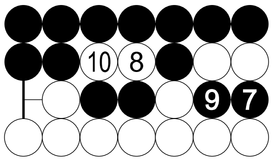

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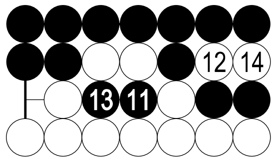

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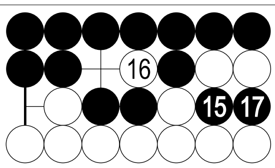
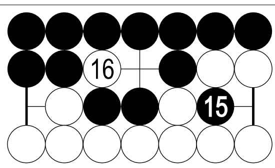
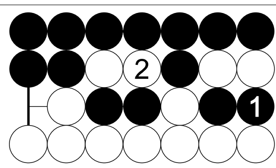


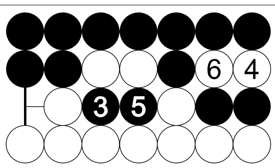
Continuation. The fixed-ko-rule prohibits White 18 at 10.



Variation 6. Start like Variation 6. Move 16 completes a situational cycle that creates the current-position.



Variation 7. White does not choose this variation because he would not prevent Black's local-area-improvement.



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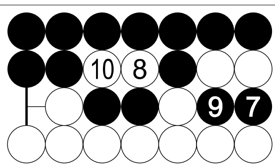

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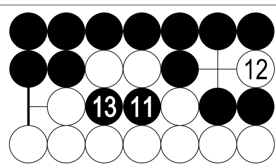
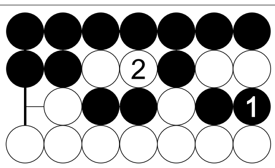
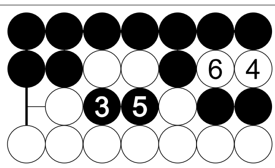


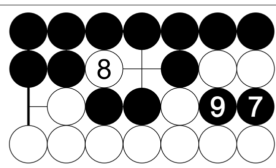
Continuation. The fixed-ko-rule prohibits White 14 at 6.



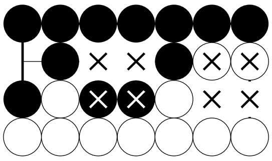
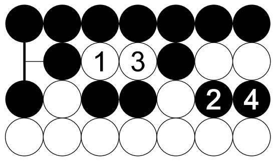
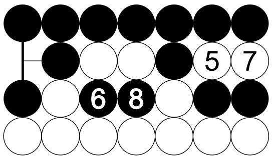
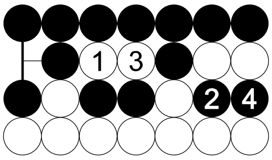
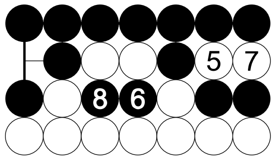
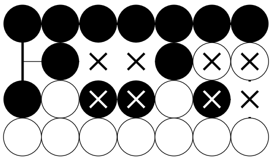
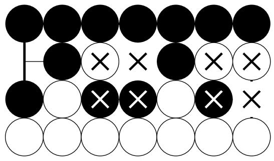
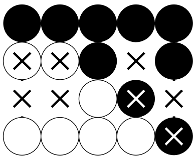
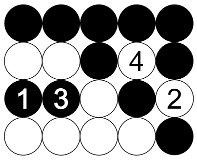
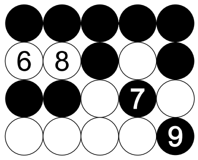
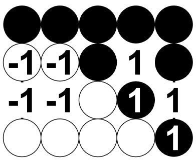
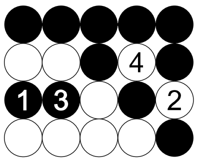
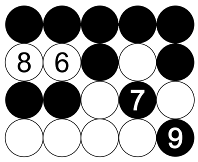
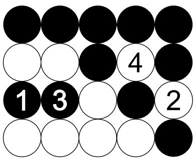
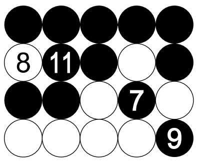
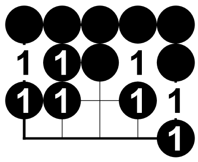
Variation 8. White does not choose this variation because he would not prevent Black's local-area-improvement.



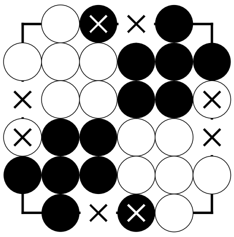
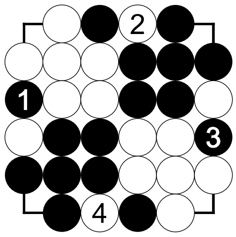
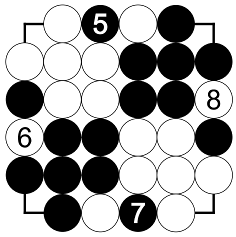
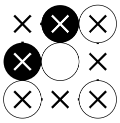
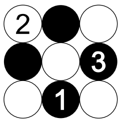
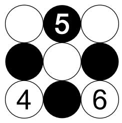
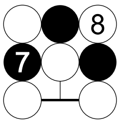
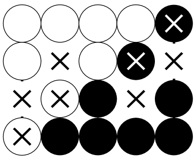
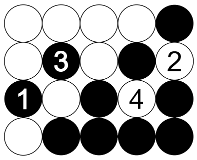
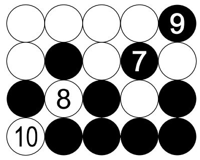
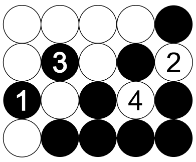
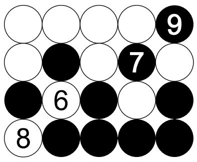
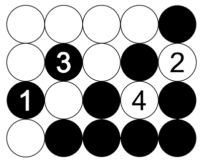
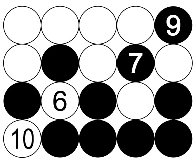
(continuation)



The fixed-ko-rule prohibits White 10 at 2.

To prevent Black's local-area-improvement, White can choose one of the Variations 2 or 6. In each of them, a situational cycle creating the current-position occurs. Therefore Black can answer-force such a cycle. Hence each of the marked intersections is a local-ko-intersection.	 **Example 10:** Each of the marked intersections is a local-ko-intersection.	 Variation 1. White should not choose capture in the basic-ko.
 (continuation)	 Variation 2. White should not choose capture in the basic-ko.	 Continuation. The opponent can alter his plays a bit. Therefore White cannot answer-force a particular cycle.
Similar sequences are possible. Black prevents White's local-area-improvement. White can answer-force some such cycle that starts at the current-position and ends with a play creating it. Therefore each of the marked intersections is a local-ko-intersection.	 **Example 11:** Each of the marked intersections is a local-ko-intersection. The start-position and sequences are analogue to Example 8. White does not get a chance to capture the basic-ko.	 **Example 12:** Each of the marked intersections is a local-ko-intersection. The sequences are analogue to Example 9. White does not get a chance to capture the basic-ko.
 **Example 13:** Each of the marked intersections is a local-ko-intersection. The shape first appeared in a game of T. Mark Hall.	 5 pass. Variation 1	 10 pass. Continuation. 10 invokes the cycle-end-rule.
 Before or after the cycle of Variation 1 or 2, the local-area is 0.	 5 pass. Variation 2	 10 pass. Continuation. 10 invokes the cycle-end-rule.
 5 pass, 6 pass. Variation 3	 10 pass, 12 pass, 13 pass, 14 pass. (continuation)	 After Variation 3, the local-area is 8, which is local-area-improvement for Black. Therefore White 6 is a strategic mistake and White does not choose Variation 3. Note that play 7 does not end the game by the cycle-end-rule.

The opponent White's only chance to prevent the player Black's local-area-improvement is a cycle like in Variation 1 or 2. In particular, since White can vary at move 6, there is more than one such cycle. Black can answer-force one of these cycles. Therefore the marked intersections are local-ko-intersections.

 **Example 14:** Each of the marked intersections is a local-ko-intersection. The cycle was discovered by Fred Hansen.		 Continuation. 8 invokes the cycle-end-rule.
The opponent White's only chance to prevent the player Black's local-area-improvement is a cycle like this. So Black can answer-force a cycle. Therefore the marked intersections are local-ko-intersections.		
 **Example 15:** Each of the marked intersections is a local-ko-intersection. If the author recalls correctly, Bill Taylor discovered pinwheel kos.	 1 at 3 for clock-wise rotation would also be possible.	 (continuation)
 Continuation. 8 invokes the cycle-end-rule.	Before or after the cycle, the local-area is -2. The opponent White's only chance to prevent the player Black's local-area-improvement is a cycle like this, which he chooses. So Black can answer-force a cycle. Therefore the marked intersections are local-ko-intersections.	
 **Example 16:** Each of the marked intersections is a local-ko-intersection. The author discovered the shape of Examples 16+17.	 5 pass, 6 pass. Variation 1. Play 10 creates the current-position.	 Continuation. 7 is allowed by the fixed-ko-rule. Moves 3 to 8 are a short cycle within the longer cycle but 8 does not invoke the cycle-end-rule because 8 does not create the start-position, which is the current-position.
 5 pass. Variation 2. Play 9 creates the current-position.	 10 pass. Continuation. Moves 3 to 7 are a short cycle within the longer cycle but 7 does not invoke the cycle-end-rule because 7 does not create the start-position, which is the current-position. 10 invokes the cycle-end-rule.	 5 pass. Variation 3. Play 10 creates the current-position.
 8 pass.	Continuation. Moves 3 to 7 are a short cycle within the longer cycle but 7 does not invoke the cycle-end-rule because 7 does not create the start-position, which is the current-position. 10 invokes the cycle-end-rule.	White prevents Black's local-area-improvement. Black can answer-force a cycle that creates the current-position. Therefore each of the marked intersections is a local-ko-intersection.

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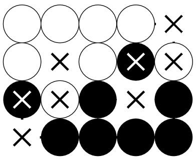
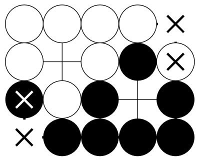
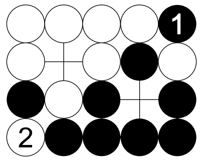
<td>
Example 17: Each of the marked intersections is a local-ko-intersection (and a basic-ko-intersection).</td>
<td>
This can be shown separately for these 4 and the other 4 intersections. (Alternative: Use Example 16 as the start-position.)</td>
<td>
3 pass,
4 pass.
Variation 1</td>
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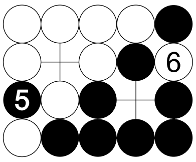
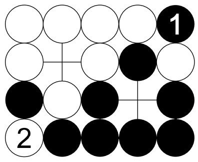
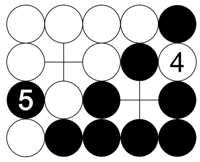
<td>
Continuation. 5 does not let the cycle-end-rule end the game. 6 invokes the cycle-end-rule and creates the current-position. Black is without local-area-improvement. 1 to 6 are a cycle.</td>
<td>
3 pass.
Variation 2</td>
<td>
6 pass.
Continuation. 5 creates the current-position. 6 invokes the cycle-end-rule. Black is without local-area-improvement; therefore it suffices that White 6 passes although White could have made a play instead. 1 to 5 are a cycle.</td>
</tr>
<tr>
<td colspan="3">By Variation 1 or 2, White prevents Black's local-area-improvement. Black can answer-force a cycle: the cycle of Variation 1 or the cycle of Variation 2. Therefore each of the 4 outer, marked intersections is a local-ko-intersection.</td>
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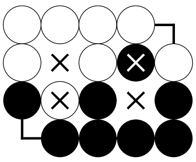
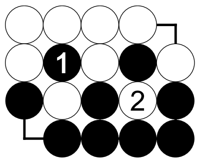
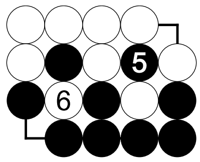
<td>
Now it is shown why the other 4 intersections are local-ko-intersections.</td>
<td>
3 pass,
4 pass.
Variation 3</td>
<td>
Continuation. 5 does not let the cycle-end-rule end the game. 6 invokes the cycle-end-rule and creates the current-position. Black is without local-area-improvement. 1 to 6 are a cycle.</td>
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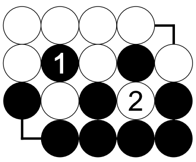
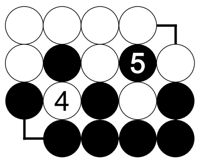
<td>
3 pass.
Variation 4</td>
<td>
6 pass.
Continuation. 5 creates the current-position. 6 invokes the cycle-end-rule. Black is without local-area-improvement; therefore it suffices that White 6 passes although White could have made a play instead. 1 to 5 are a cycle.</td>
<td>By Variation 3 or 4, White prevents Black's local-area-improvement. Black can answer-force a cycle: the cycle of Variation 3 or the cycle of Variation 4. Therefore each of the 4 inner, marked intersections is a local-ko-intersection.</td>
</tr>
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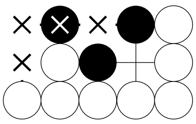
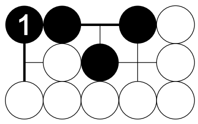
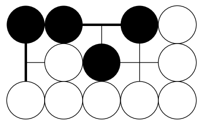
<td>
Example 18: Each of the marked intersections is a local-ko-intersection.</td>
<td>
2 pass,
3 pass,
4 pass.
Variation 1 from the current-position as the start-position. Black gets local-area-improvement.</td>
<td>
Start-position of Variations 2-4.</td>
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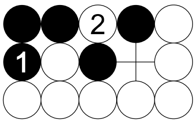
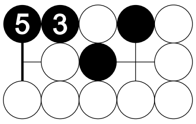
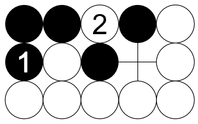
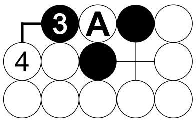
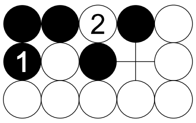
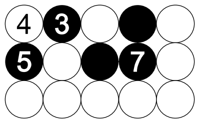
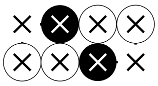
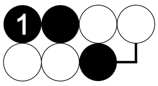
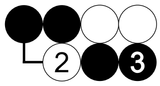
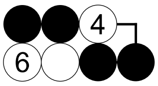
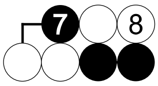
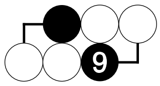
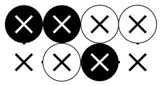
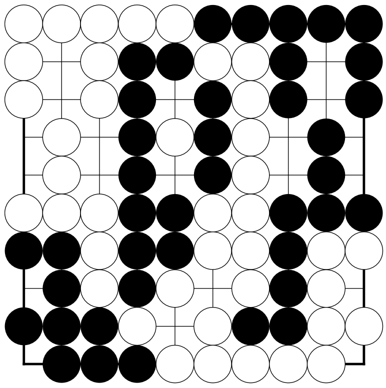
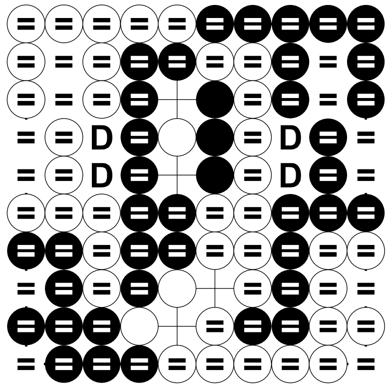
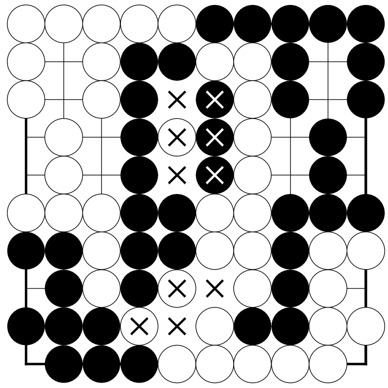
<td>
Variation 2</td>
<td>
4 pass,
6 pass.
Continuation. 6 invokes the cycle-end-rule. 3 creates the current-position. 1 to 5 are a cycle. Black is without local-area-improvement.</td>
<td>
Variation 3</td>
</tr>
<tr>
<td>
5 at A.
Continuation. White does not choose Variation 3 because Black would remove all white stones, i.e., White would not prevent Black's local-area-improvement.</td>
<td>
Variation 4</td>
<td>
6 pass,
8 pass,
9 pass,
10 pass.
Continuation. White does not choose Variation 4 because Black would remove all white stones, i.e., White would not prevent Black's local-area-improvement.</td>
</tr>
<tr>
<td colspan="3">The start-position of Variations 2-4 allows a suitable cycle for the definition of local-ko-intersection. By choosing Variation 2, the opponent White prevents the player Black's local-area-improvement. Black can answer-force the cycle in Variation 2. Therefore each of the marked intersections is a local-ko-intersection.</td>
</tr>
<tr>
<td>
Example 19: Each of the marked intersections is a local-ko-intersection. Bill Taylor discovered the diamond ko in Examples 19+20.</td>
<td>
The sequence is one of the possible cycles.</td>
<td>
(continuation)</td>
</tr>
<tr>
<td>
5 pass.
(continuation)</td>
<td>
(continuation)</td>
<td>
10 pass.
Continuation. 10 invokes the cycle-end-rule.</td>
</tr>
<tr>
<td colspan="2">White's only chance to prevent Black's local-area-improvement is to follow a cycle. Black can answer-force one of the cycles. Therefore each of the marked intersections is a local-ko-intersection.</td>
<td>
Example 20: Each of the marked intersections is a local-ko-intersection.</td>
</tr>
</table>



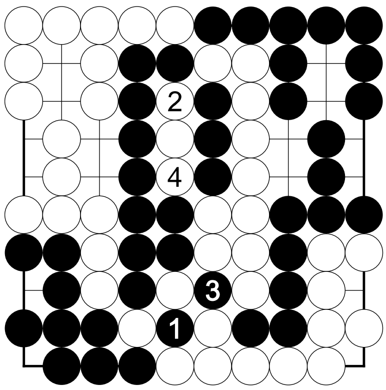
Example 21: The position is from the Ing 1991 Rules booklet. According to rumours, Matti Siivola discovered triple ko stones.



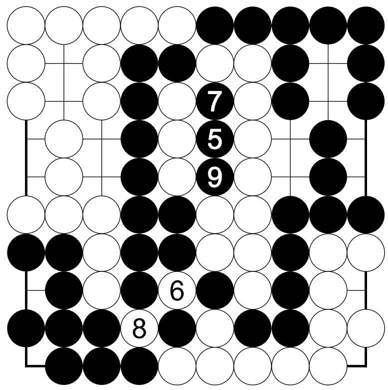
The marked area's score is 0. There is an even number of dame D. Therefore the excitement is confined to the duty of living with either player's big center string and competing for the remaining intersections.



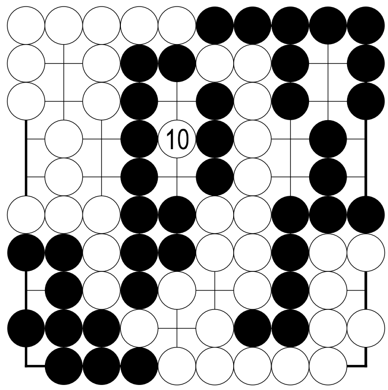
These are the interesting intersections. Each of them is a local-ko-intersection. The upper part consists of 6 intersections. The lower part consists of only 4 intersections but decides about the connection in case of missing two eyes in the upper part.



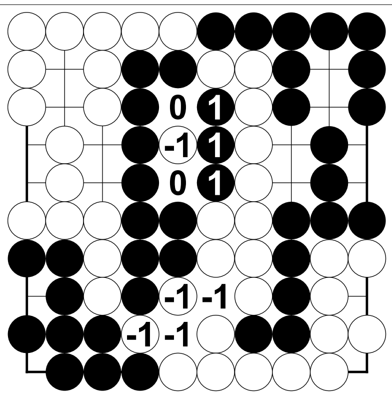
Variation 1: a representative cycle.



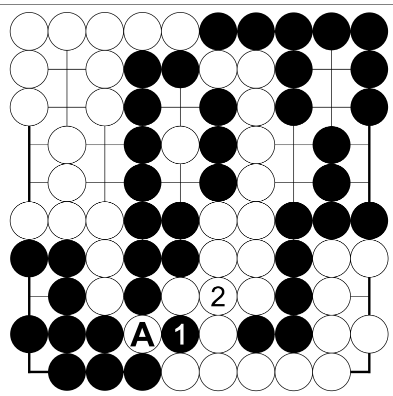
(continuation)



Continuation. Moves 1 to 10 are a cycle. Move 10 creates the current-position and invokes the cycle-end-rule.

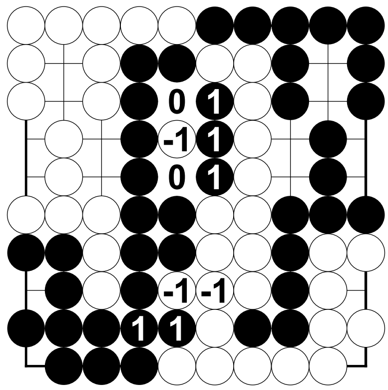


Before or after the cycle of Variation 1, the score, as indicated by the local-area, is -2. This is without Black's local-area-improvement.

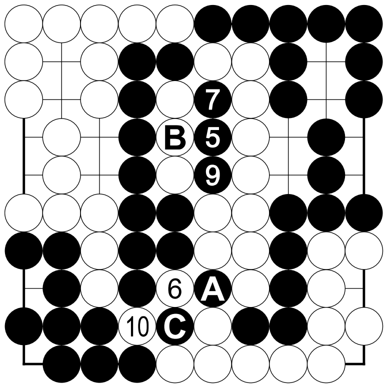


3 at A.

Variation 2

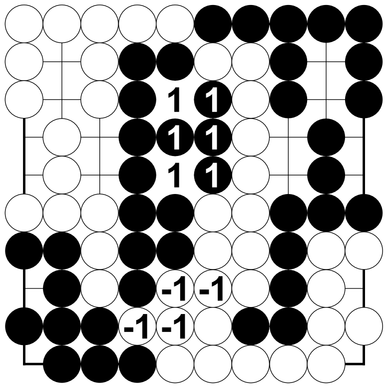


After Variation 2, the local-area is 2. By choosing this variation, White would not prevent Black's local-area-improvement.



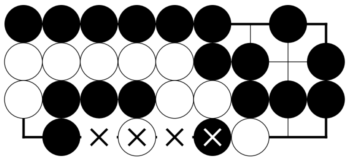
8 at A, 11 at B, 12 at C.

Variation 3: departing from the cycle.

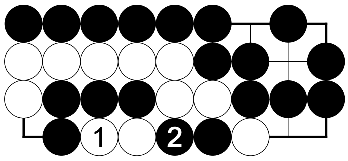


After Variation 3, the local-area is 2. By choosing this variation, White would not prevent Black's local-area-improvement.

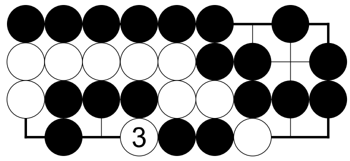
Hence, to prevent Black's local-area-improvement, White has to follow a cycle. Black can answer-force one of the cycles like the one of Variation 1. Therefore each of the marked intersections is a local-ko-intersection. This is remarkable because it means that one does not need to calculate the whole board score or perfect-play to identify a triple ko stones cycle cycle-set's intersections as ko-intersections. In other words, the triple ko stones here do not require a different type of ko-intersection.



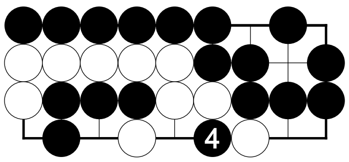
Example 22: Each of the marked intersections is a local-ko-intersection.



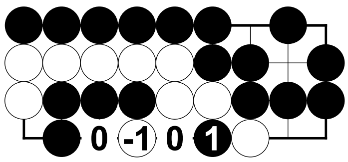
Variation 1



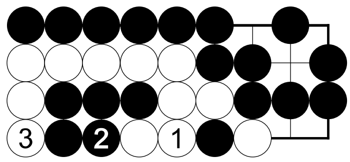
(continuation)



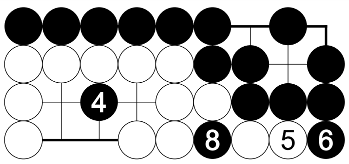
Continuation. 4 invokes the cycle-end-rule.



Before or after the cycle, the local-area is 0. White is without local-area-improvement.

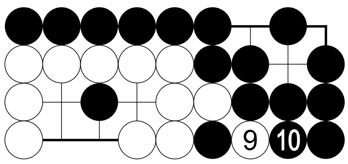


Variation 2



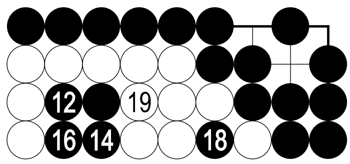
7 pass.

(continuation)



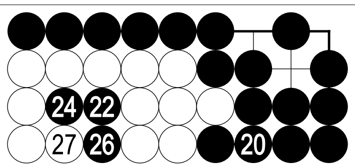
11 pass.

(continuation)



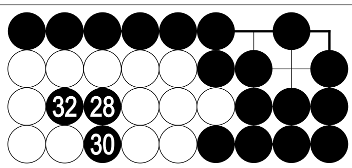
13 pass, 15 pass,
17 pass.

(continuation)



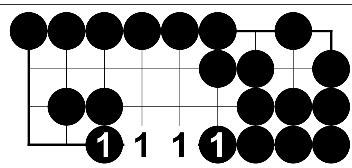
21 pass, 23 pass,
25 pass.

(continuation)



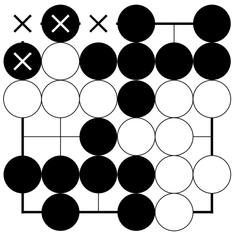
29 pass, 31 pass,
33 pass, 34 pass,
35 pass.

(continuation)

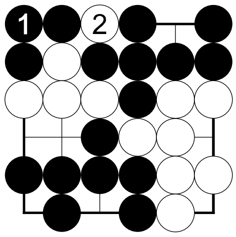


After the sequence, the local-area is 4. Also Variation 2 is without White's loca-area-improvement on the Variation 1 cycle's cycle-set.

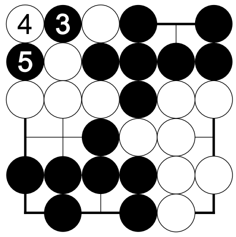
Although the cycle is not played in Variation 2, for the purpose of the definition, it suffices that the cycle fulfilling the conditions exists. It suffices that, since, to fulfil the definition of local-ko-intersection, White has to answer-force a cycle, White chooses Variation 1 instead of Variation 2. - White answer-forces a cycle, the cycle of Variation 1, on the marked intersections. Play 4 of the cycle in Variation 1 creates the current-position. Each of the marked intersections belongs to the cycle's cycle-set. Hence each is a local-ko-intersection. - It suffices that a cycle starting with White moving first and fulfilling the definition exists. One does not need to study Black moving first. At least one player must answer-force a cycle. It is not required that both players can because the definition asks only for "a player".



Example 23: The position is by Herman Hiddema, who thereby rediscovered some cycle with 5 plays.

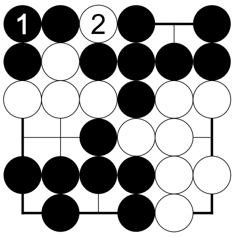


Cycle 1: A cycle from move 1 to 5. The start-position is the current-position.

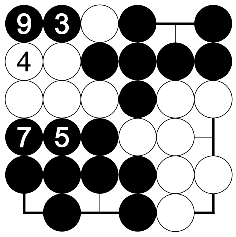


⑥ pass.

Continuation. 5 creates the current-position. 6 invokes the cycle-end-rule.

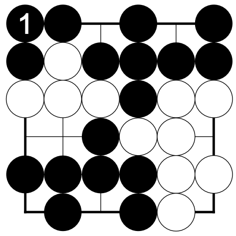


Variation 1.1



⑥ pass,
⑧ pass,
⑩ pass,
⓫ pass,
⑫ pass.

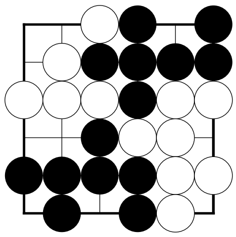
(continuation)



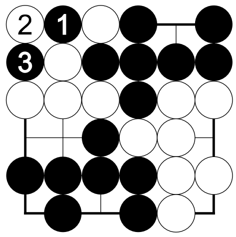
② pass,
❸ pass,
④ pass.

Variation 1.2

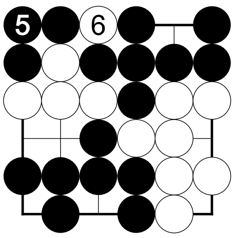
In Cycle 1 and Variations 1.1 and 1.2, the opponent White prevents the player Black's local-area-improvement. White can choose, e.g., Variation 1.2. Black cannot answer-force the cycle in Cycle 1. Therefore the cycle in Cycle 1 does not fit the definition of local-ko-intersection.



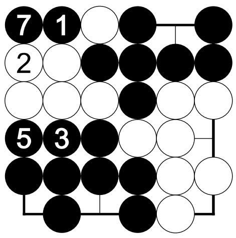
Cycle 2: Start-position of a cycle. Play 3 creates the current-position.



④ pass.

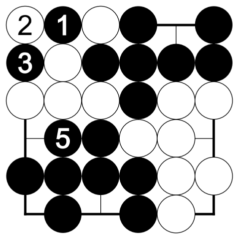


Continuation. Moves 1 to 6 are a cycle. 6 creates the current-position and invokes the cycle-end-rule. Black is without local-area-improvement.



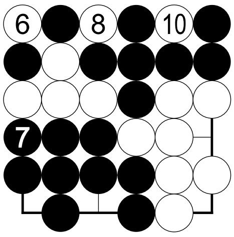
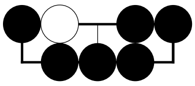
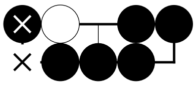
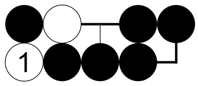
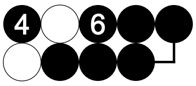
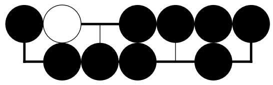
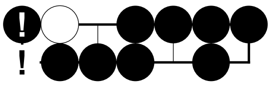
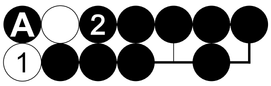
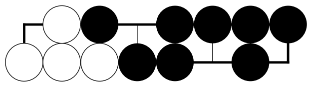
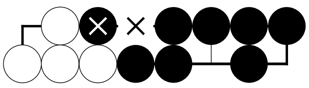
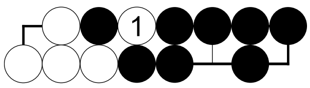
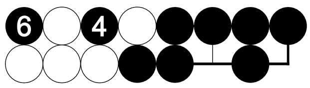
④ pass,
⑥ pass,
⑧ pass,
❾ pass,
⑩ pass.

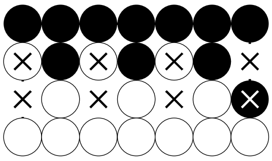
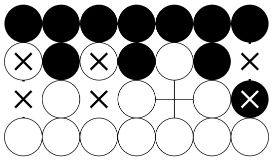
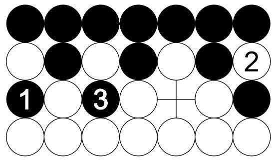
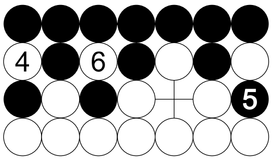
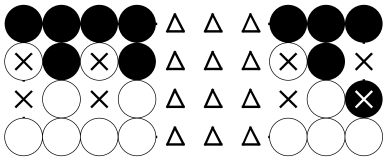
Variation 2.1: White may not choose 2 because then he does not prevent Black's local-area-improvement.



④ pass.

Variation 2.2: If Black had to choose this variation, then the opponent White could prevent the player Black's local-area-improvement.

 9 pass, 11 pass, 12 pass, 13 pass. (continuation)	To answer-force a cycle, Black chooses Cycle 2 rather than Variation 2.2. The Cycle 2 study shows that the marked intersections are local-ko-intersections.	
 **Example 24**	 Each of the marked basic-ko-intersections is a local-ko-intersection.	 2 pass, 3 pass.
 5 pass, 7 pass, 8 pass, 9 pass. Continuation. Move 4 does not invoke a game end by the cycle-end-rule.	While Black prevents White's local-area-improvement, White answer-forces the cycle 1 to 4. Therefore each of the marked intersections is a local-ko-intersection.	 **Counter-example 25**
 Even none of the marked basic-ko-intersections is a local-ko-intersection.	 3 pass, 4 at A, 5 pass, 6 pass, 7 pass. While Black prevents White's local-area-improvement, White cannot answer-force a cycle.	 **Example 26**
 Each of the marked basic-ko-intersections is a local-ko-intersection.	 2 pass, 3 pass.	 5 pass, 7 pass, 8 pass, 9 pass. Continuation. Move 4 does not invoke a game end by the cycle-end-rule. While Black prevents White's local-area-improvement, White answer-forces the cycle 1 to 4. Therefore each of the marked intersections is a local-ko-intersection.

 **Example 27:** Instable quadruple ko. Each of the marked intersections is a local-ko-intersection. Since the two right-most marked intersections are not basic-ko-intersections, it is interesting to know that also they are local-ko-intersections.	 Proving local-ko-intersections can be done, e.g., by analysing three pairs of two adjacent intersections at a time, then doing an analogue analysis for other three pairs including the right-most.	
 Continuation. 6 invokes the cycle-end-rule. To prevent Black's local-area-improvement, White needs to make the captures. Black can answer-force the cycle 1 to 6. Therefore each of the marked intersections is a local-ko-intersection.	 **Example 28:** Instable n-tuple-ko (n>4). Each of the crossed intersections is a local-ko-intersection. Since the two right-most crossed intersections are not basic-ko-intersections, it is interesting to know that also they are local-ko-intersections. (In stable n-tuple-kos, there are 2n basic-ko-intersections anyway.)	To avoid effective White stone connections, proving local-ko-intersections must be done for all the 2n crossed intersections together. Due to Propositions 1-4, Black can answer-force a cycle of Proposition 1 if White prevents Black's local-area-improvement. Hence each of the crossed intersections is a local-ko-intersection.

Propositions for Example 28

Proposition 1: If White makes only basic-ko captures and prevents Black's local-area-improvement, then Black can answer-force a cycle that starts from the current-position and has all crossed intersections as its cycle-set.

Proof: In the current-position, the local-area is 4 - 2n. Whenever, from a position with that local-area, Black makes a basic-ko capture, this improves the local-area for him to 8 - 2n. To prevent Black's local-area-improvement, White must reply by a basic-ko capture (if White passes, then a) Black having 3 open basic-kos connects a stone or else b) Black improves the local-area by another basic-ko capture yet further in his favour). Due to the basic-ko-rule, White may not recapture the same basic-ko immediately, i.e., White has to capture another basic-ko. In particular, White's first basic-ko capture captures the right-most basic-ko. Black chooses to capture the left-most basic-ko that he has not captured yet. White follows suit necessarily. Thereby on all the crossed intersections plays will be made until Black's right-most capture creates the current-position. This is the first occurrence of a cycle, which is situational, invokes the cycle-end-rule and has never violated the fixed-ko-rule. QED.

Proposition 2: If already n - 4 stones have been connected, 2 basic-kos are open for Black and 2 basic-kos are open for White, then after White's connection of another stone White cannot prevent Black's local-area-improvement.

Proof: Next Black captures all white stones. QED.

Proposition 3: If at some time White connects a stone instead of making a basic-ko capture, fewer than n - 4 stones have already been connected and after the newly connected stone White does not connect yet another stone, then White cannot prevent Black's local-area-improvement.

Proof: If Black - according to the proof of Proposition 1 - has 3 open basic-kos, then Black connects a stone; else Black passes. This leads to a situation with exactly 2 basic-kos open for Black, m>2 basic-kos open for White and White to move. Assuming without loss of generality the attacked Black then always captures the left-most basic-ko that currently he may capture, then 6 plays are like a tiple ko cycle, afterwards 2 successive passes enable White a basic-ko recapture and afterwards 6 plays for the other triple-ko-like cycle on the same 6 intersections let White finally run out of options (other than passing) due to the fixed-ko-rule (while the moves before were not prohibited by the fixed-ko-rule and did not invoke a game end due to the cycle-end-rule). This will lead to some position with the local-area of at least 8 - 2n and White does not prevent Black's local-area-improvement compared to the local-area 4 - 2n of the current-position. QED.

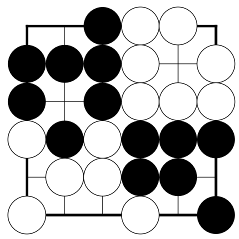
Proposition 4: If more and more stones are connected as in Propositions 1 or 3, then at some time the assumptions of Proposition 2 will be invoked.

Proof: Trivial.

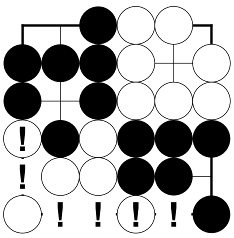
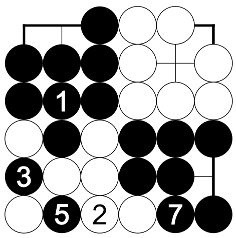
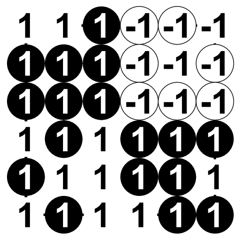
Global-ko-intersection

Territory scoring is assumed to be defined as in the Japanese 2003 Rules / version 35a. The variations are selected so that the effect of dame letting independently-alive groups be in-seki is irrelevant in practice.

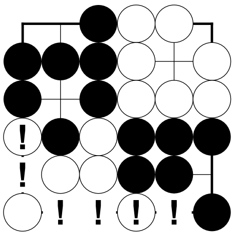
Counter-example 1



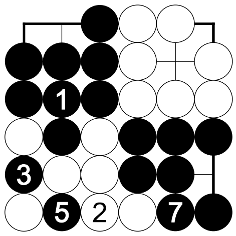
Counter-example 1 - Area Scoring, Komi = 18, Black to Move

 In particular, none of the marked intersections is a global-ko-intersection.	 4 pass, 6 pass, 8 pass, 9 pass, 10 pass.	 Score = 27 - 9 - 18 = 0. While White prevents Black's win, Black cannot answer-force a cycle. Therefore none of the marked intersections is a global-ko-intersection.

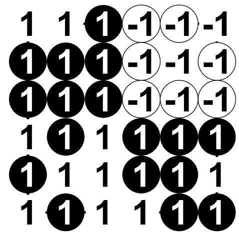
Counter-example 2 - Area Scoring, Komi = 17.5, Black to Move



In particular, none of the marked intersections is a global-ko-intersection.

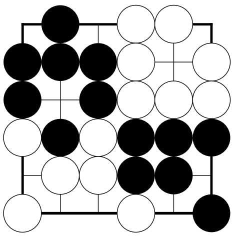
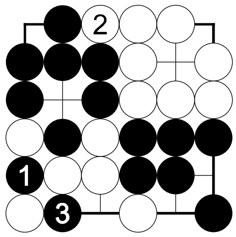
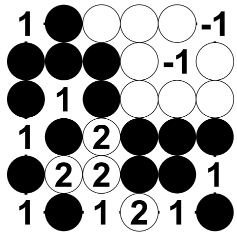
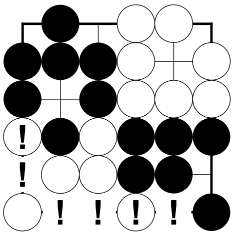


④ pass,
⑥ pass,
⑧ pass,
❾ pass,
⑩ pass.

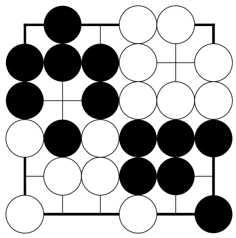


Score = 27 - 9 - 17.5 = 0.5.
White cannot prevent Black's win.
Therefore none of the marked intersections is a global-ko-intersection.

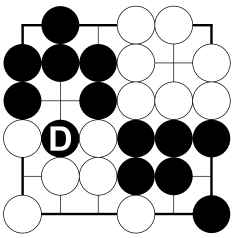
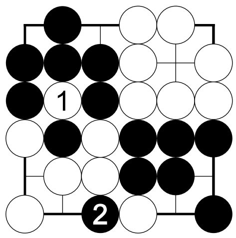
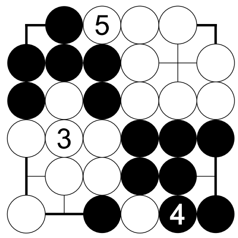
Counter-example 3 - Territory Scoring, Komi = 15, Black to Move

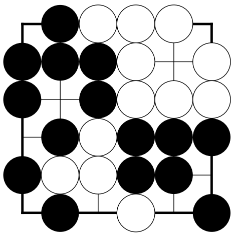
	 4 pass, 5 pass, 6 pass. Variation. Prisoner-difference = 2.	 Score = 15 - 2 + 2 - 15 = 0. White does prevent Black's win. Black cannot answer-force a cycle.
	Therefore in particular none of the marked intersections is a global-ko-intersection.	

Example 4 - Territory Scoring, Komi = 14.5, Black to Move

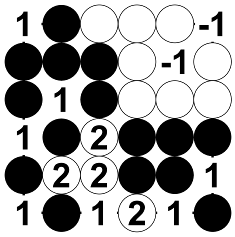


Example 4 - Relevant Scoring Positions

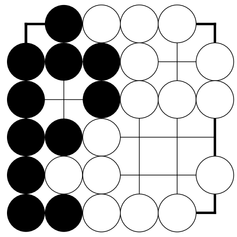
 Scoring Position 1. Black wants to avoid this scoring position because, e.g., in particular the stone D is dead.	 This representative hypothetical-sequence indicates why D is dead.	 Continuation. The marked stone is not capturable-2 either because, in the move-sequence, White can remove all the black stones.



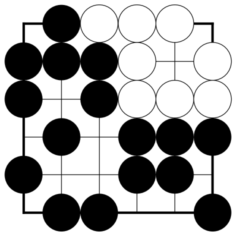
Scoring Position 2. The prisoner-difference is 2.



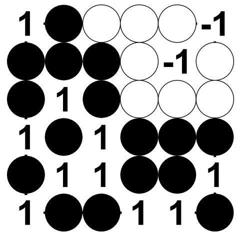
Score = 15 - 2 + 2 - 14.5 = 0.5. White wants to avoid this scoring position because he does not prevent Black's win.



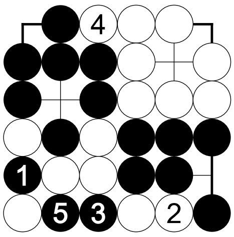
Scoring Position 3. The prisoner-difference is -4. Obviously Black wants to avoid this scoring position.



Scoring Position 4. The prisoner-difference is 7.

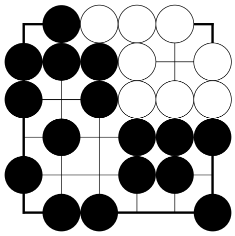


Score = 10 - 2 + 7 - 14.5 = 0.5. White wants to avoid this scoring position because he does not prevent Black's win.

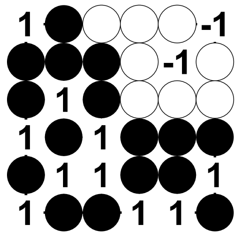


6 pass,
7 pass,
8 pass.

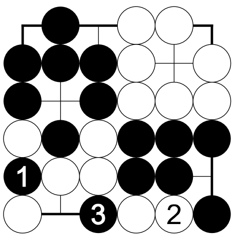
Variation 4.1 creating Scoring Position 4.



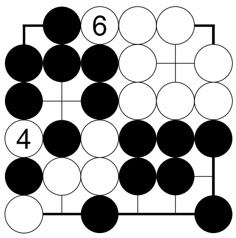
Scoring Position 5. The prisoner-difference is 7.



Score = 10 - 2 + 7 - 14.5 = 0.5. White wants to avoid this scoring position because he does not prevent Black's win.

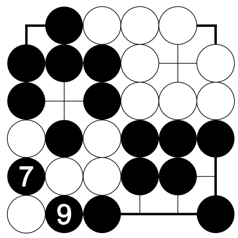


Variation 5.1 creating Scoring Position 5.



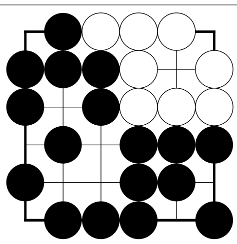
5 pass.

(continuation)

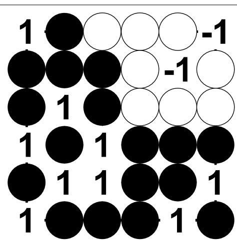


8 pass,
10 pass,
11 pass,
12 pass.

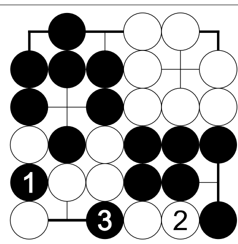
(continuation)



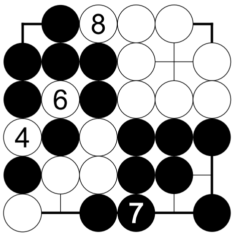
Scoring Position 6. The prisoner-difference is 7.



Score = 9 - 2 + 7 - 14.5 = -0.5.

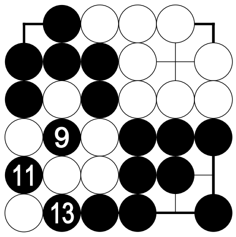


Variation 6.1 creating Scoring Position 6.



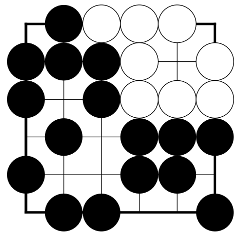
5 pass.

(continuation)

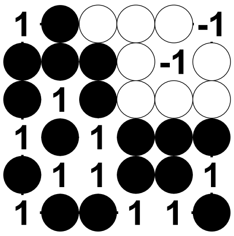


10 pass,
12 pass,
14 pass,
15 pass,
16 pass.

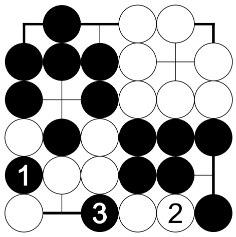
Continuation. Black has to eliminate all the kos so that none of his strings is dead.



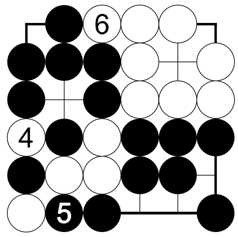
Scoring Position 7. The prisoner-difference is 7.



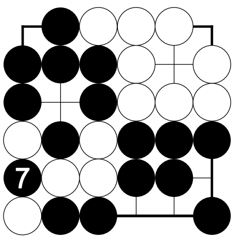
Score = 10 - 2 + 7 - 14.5 = 0.5. White wants to avoid this scoring position because he does not prevent Black's win.



Variation 7.1 creating Scoring Position 7.

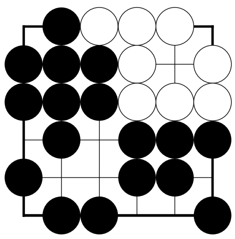


(continuation)

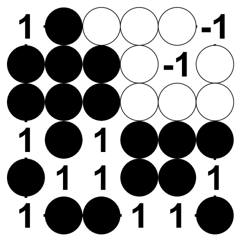


8 pass,
9 pass,
10 pass.

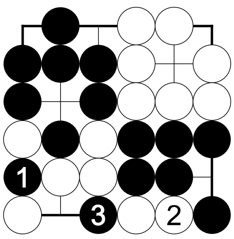
(continuation)



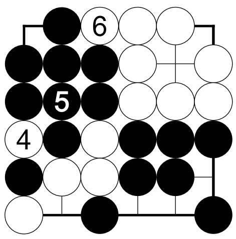
Scoring Position 8. The prisoner-difference is 7.



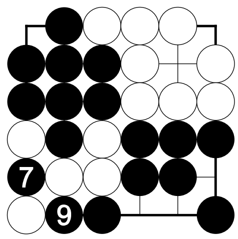
Score = 9 - 2 + 7 - 14.5 = -0.5. Black wants to avoid this scoring position.



Variation 8.1 creating Scoring Position 8.



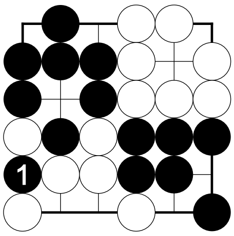
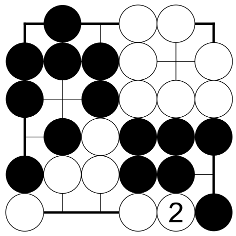
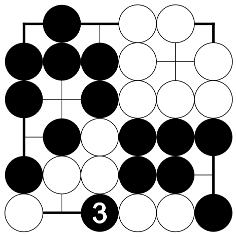
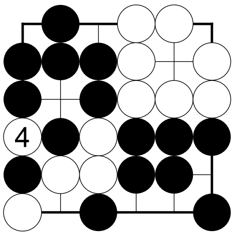
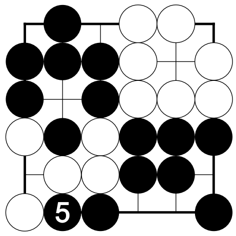
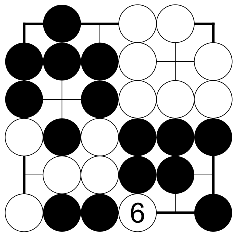
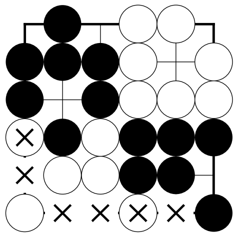
(continuation)



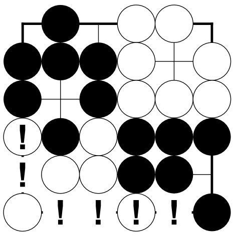
8 pass,
10 pass,
11 pass,
12 pass.

(continuation)

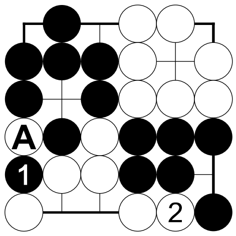
Example 4 - Decisions Creating the Cycle

 Move 1	White does prevent Black's win: 1) If Black 1 passes, then Scoring Position 1 can occur. 2) If Black chooses move 1, then see below.	 Move 2
White does not fill the dame: This would lead to Scoring Position 2. White would not prevent Black's win.	 Move 3	White does prevent Black's win: 1) If Black 1 captures the lower left corner stone, then Scoring Position 3 can occur. 2) If Black chooses move 3, then see below.
 Move 4	White does not fill the dame: This would lead to Scoring Position 4. White would not prevent Black's win.	 Move 5
White does prevent Black's win: 1) If Black 5 passes, then Scoring Position 6 can occur. (White does not choose Variation 5.1.) 2) If Black 5 connects, then Scoring Position 8 can occur. 3) If Black chooses move 5, then see below.	 Move 6	1) White does not fill the dame: This would lead to Scoring Position 7. White would not prevent Black's win. 2) By choosing move 6, White does prevent Black's win, as Scoring Position 1 shows. Move 6 invokes the cycle-end-rule.
Summarizing the implication of all decisions: White does prevent Black's win. Black answer-forces a cycle, which occurs at move 6. The cycle starts from the current-position and, in the cycle, move 6 creates the current-position. Therefore, in the following diagram, each of the marked intersections is a global-ko-intersection.		

Example 4 - None of the Marked Intersections is a Local-ko-intersection

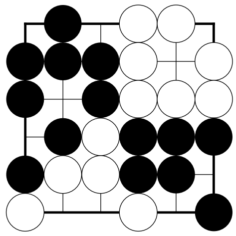


In particular none of the marked intersections is a local-ko-intersection. In the following diagrams, the local-area-improvement is calculated on these intersections.

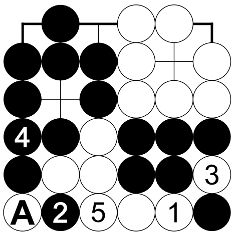


3 at A,
4 pass,
5 pass,
6 pass.

Variation 1. White cannot prevent Black's local-area-improvement from -5 to -2.

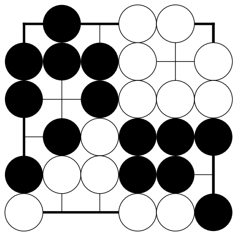


Starting position of Variation 2.

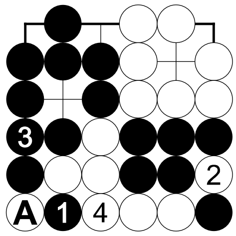


6 at A,
7 pass,
8 pass,
9 pass.

Variation 2. White cannot prevent Black's local-area-improvement from -1 to 0.

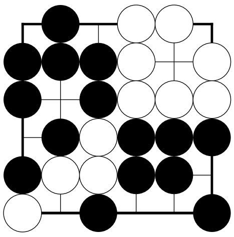


Starting position of Variation 3.

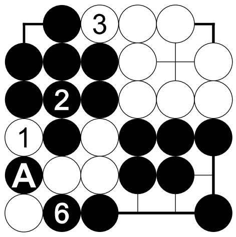


5 at A,
6 pass,
7 pass,
8 pass.

Variation 3. White cannot prevent Black's local-area-improvement from -2 to 0.

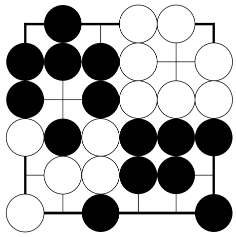


Starting position of Variation 4.

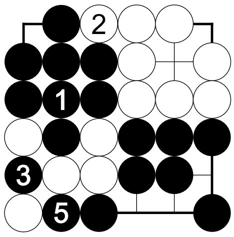


4 at A,
5 pass,
7 pass,
8 pass,
9 pass.

Variation 4. White cannot prevent Black's local-area-improvement from 5 to 6.

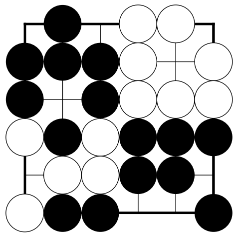


Starting position of Variation 5.

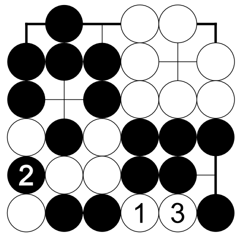


4 pass,
6 pass,
7 pass,
8 pass.

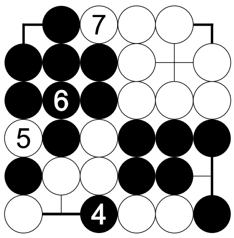
Variation 5. White cannot prevent Black's local-area-improvement from 1 to 6.



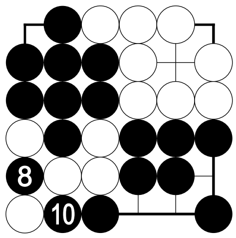
Starting position of Variation 6.



Variation 6. White cannot prevent Black's local-area-improvement from 2 to 6.



(continuation)

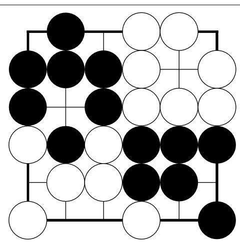


9 pass,
11 pass,
12 pass,
13 pass.

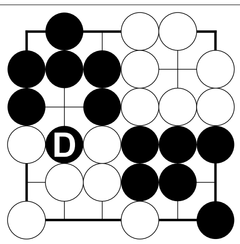
(continuation)

Summary of Variations 1-6 and similar variations: None of the marked intersections is a local-ko-intersection.

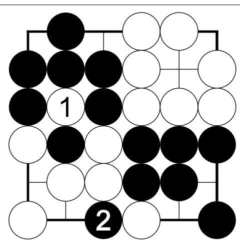
Example 5 - Territory Scoring, Komi = 14, Black to Move



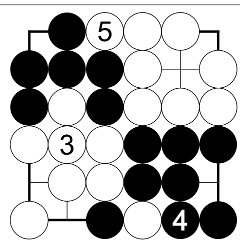
Example 5 - Relevant Scoring Positions



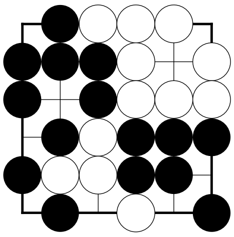
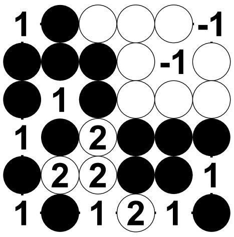
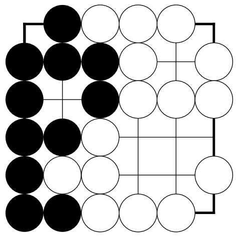
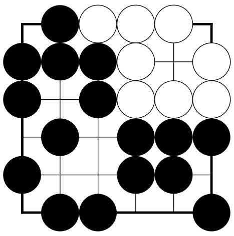
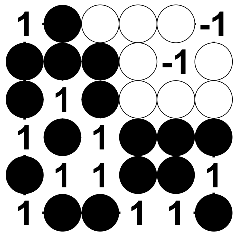
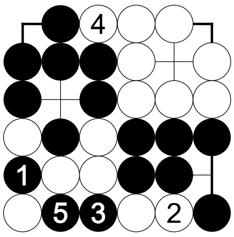
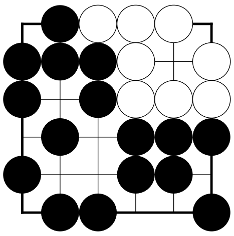
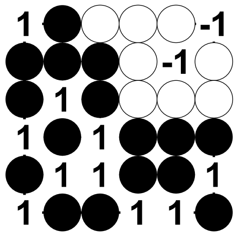
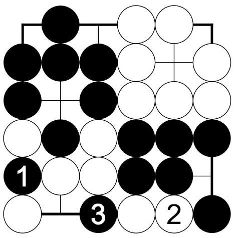
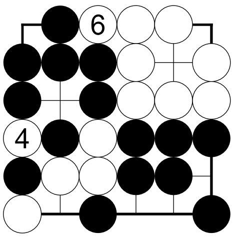
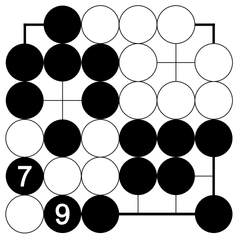
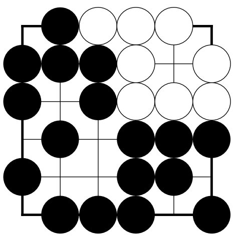
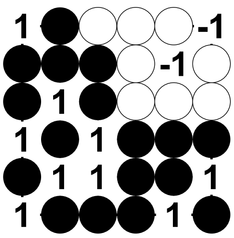
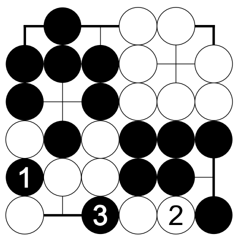
Scoring Position 1. Black wants to avoid this scoring position because, e.g., in particular the stone D is dead.

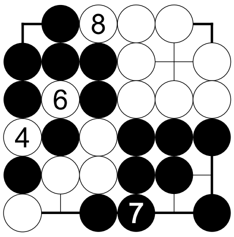


This representative hypothetical-sequence indicates why D is dead.



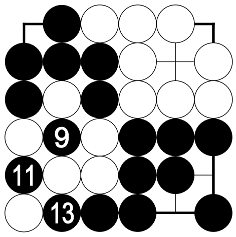
Continuation. The marked stone is not capturable-2 either because, in the move-sequence, White can remove all the black stones.

 Scoring Position 2. The prisoner-difference is 2.	 Score = 15 - 2 + 2 - 14 = 1.	 Scoring Position 3. The prisoner-difference is -4. Obviously Black wants to avoid this scoring position.
	 Scoring Position 4. The prisoner-difference is 7.	 Score = 10 - 2 + 7 - 14 = 1.
 6 pass, 7 pass, 8 pass. Variation 4.1 creating Scoring Position 4.	 Scoring Position 5. The prisoner-difference is 7.	 Score = 10 - 2 + 7 - 14 = 1.
 Variation 5.1 creating Scoring Position 5.	 5 pass. (continuation)	 8 pass, 10 pass, 11 pass, 12 pass. (continuation)
 Scoring Position 6. The prisoner-difference is 7.	 Score = 9 - 2 + 7 - 14 = 0.	 Variation 6.1 creating Scoring Position 6.



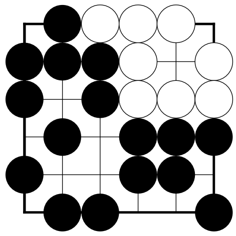
5 pass.

(continuation)

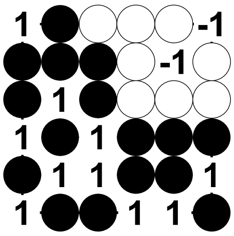


10 pass,
12 pass,
14 pass,
15 pass,
16 pass.

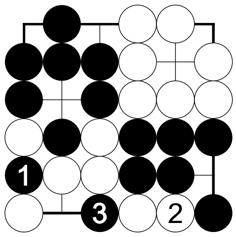
Continuation. Black has to eliminate all the kos so that none of his strings is dead.



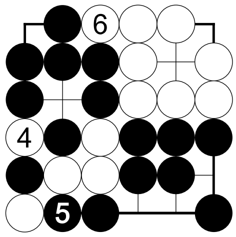
Scoring Position 7. The prisoner-difference is 7.



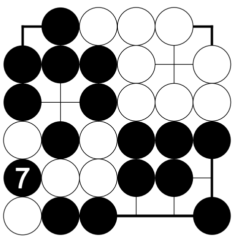
Score = 10 - 2 + 7 - 14 = 1.
White wants to avoid this scoring position because he does not prevent Black's win.



Variation 7.1 creating Scoring Position 7.

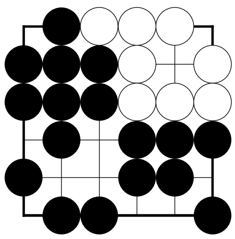


(continuation)

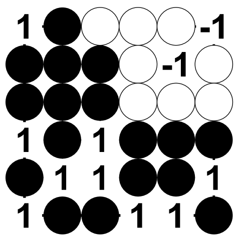


8 pass,
9 pass,
10 pass.

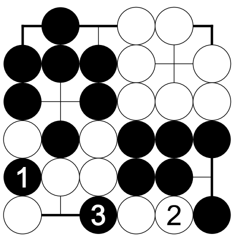
(continuation)



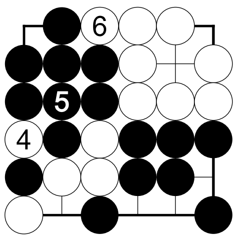
Scoring Position 8. The prisoner-difference is 7.



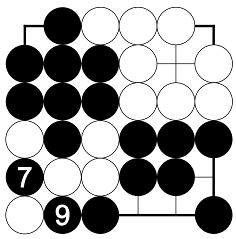
Score = 9 - 2 + 7 - 14 = 0.



Variation 8.1 creating Scoring Position 8.



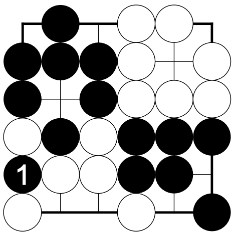
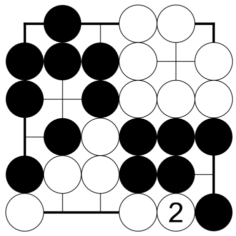
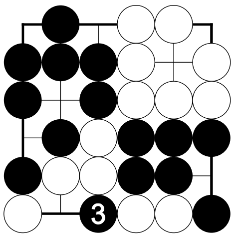
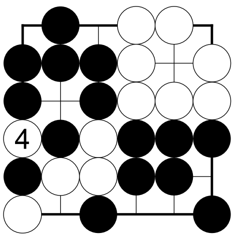
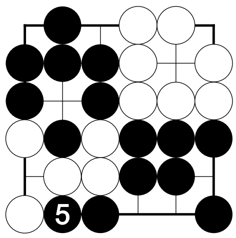
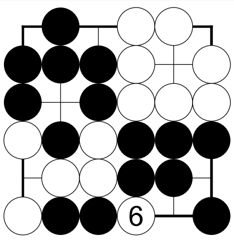
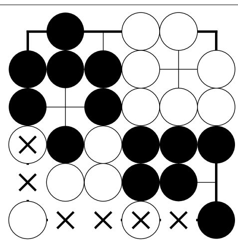
(continuation)



8 pass,
10 pass,
11 pass,
12 pass.

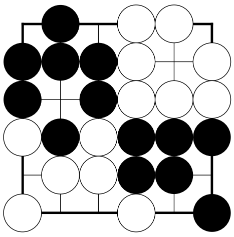
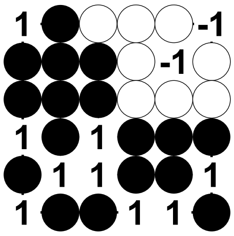
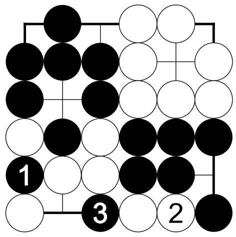
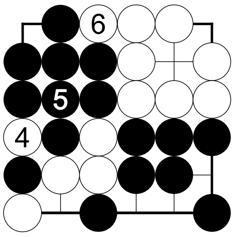
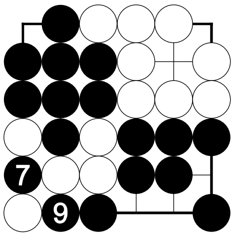
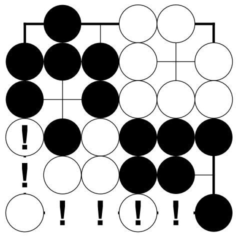
(continuation)

Example 5 - Decisions Creating the Cycle

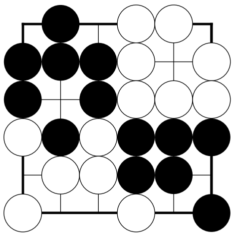
 Move 1	White does prevent Black's win: 1) If Black 1 passes, then Scoring Position 1 can occur. 2) If Black chooses move 1, then see below.	 Move 2
Instead of move 2, White does not fill the dame: This would lead to Scoring Position 2. White does prevent Black's win: see below.	 Move 3	White does prevent Black's win: 1) If Black 3 captures the lower left corner stone, then Scoring Position 3 can occur. 2) If Black chooses move 3, then see below.
 Move 4	Instead of move 4, White cannot fill the dame: This would lead to Scoring Position 4. White would not prevent Black's win. Therefore White choose move 4 to prevent Black's win, see below.	 Move 5
White does prevent Black's win: 1) If Black 5 passes, then Scoring Position 6 can occur. (White does not choose Variation 5.1.) 2) If Black 5 connects, then Scoring Position 8 can occur. 3) If Black chooses move 5, then see below.	 Move 6	1) White does not fill the dame: This would lead to Scoring Position 7. White would not prevent Black's win. 2) By choosing move 6, White does prevent Black's win, as Scoring Position 1 shows. Move 6 invokes the cycle-end-rule.
Summarizing the implication of all decisions: White does prevent Black's win. Black answer-forces a cycle, which occurs at move 6. The cycle starts from the current-position and, in the cycle, move 6 creates the current-position. Therefore, in the following diagram, each of the marked intersections is a global-ko-intersection.		

Counter-example 6 - Territory Scoring, Komi = 13.5, Black to Move

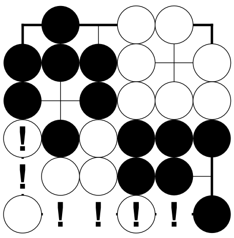
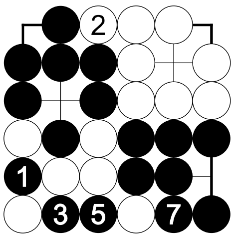
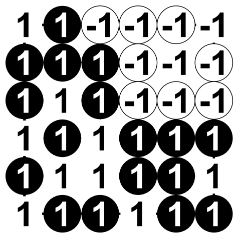
The analysis is like in Example 5, except that the score of every scoring position is 0.5 greater. At move 5, this gives Black another option to choose Scoring Position 8. Therefore the conclusion differs, too.

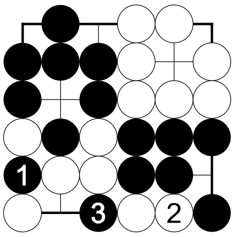
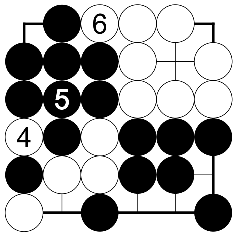
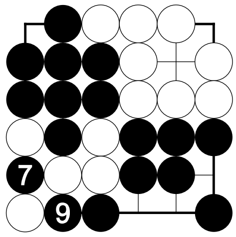
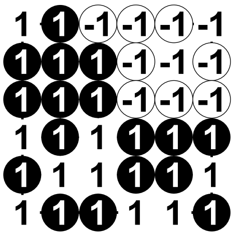
	 Scoring Position 8. The prisoner-difference is 7. Score = 9 - 2 + 7 - 13.5 = 0.5.	 Variation 8.1 creating Scoring Position 8.
 (continuation)	 8 pass, 10 pass, 11 pass, 12 pass. (continuation)	 White cannot prevent Black's win. Therefore in particular none of the marked intersections is a global-ko-intersection.

Counter-example 7

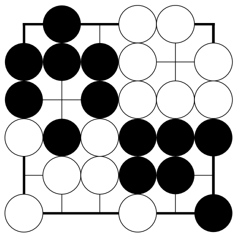


Counter-example 7 - Area Scoring, Komi = 15.5, Black to Move

 In particular, none of the marked intersections is a global-ko-intersection.	 4 pass, 6 pass, 8 pass, 9 pass, 10 pass. Variation 1	 Scoring position after Variation 1. Score = 26 - 10 - 15.5 = 0.5. By Variation 1, White does not prevent Black's win. Therefore White's only chance is to create a cycle.

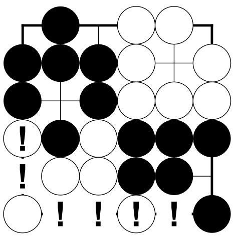
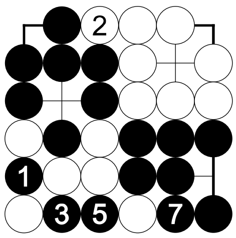
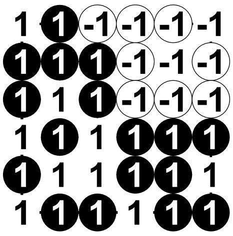
 Variation 2	 (continuation)	 8 pass, 10 pass, 11 pass, 12 pass. (continuation)
 Scoring position after Variation 2. Score = 26 - 10 - 15.5 = 0.5. By Variation 2, White does not prevent Black's win, either.	Since White cannot prevent Black's win, none of the marked intersections is a global-ko-intersection.	

Counter-example 8



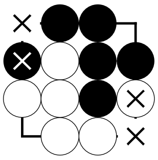
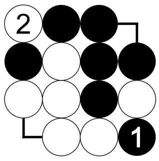
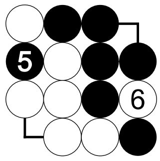
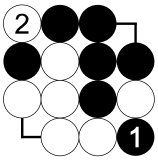
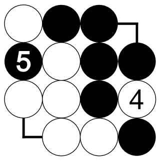
Counter-example 8 - Area Scoring, Komi = 16, Black to Move

While, for this position an some appropriate komi, under territoy scoring global-ko-intersections can exist, under area scoring they do not exist for this position.

 In particular, none of the marked intersections is a global-ko-intersection.	 4 pass, 6 pass, 8 pass, 9 pass, 10 pass. Representative sequence.	 Score = 26 - 10 - 16 = 0. White does prevent Black's win. Black cannot answer-force a cycle. Therefore none of the marked intersections is a global-ko-intersection.

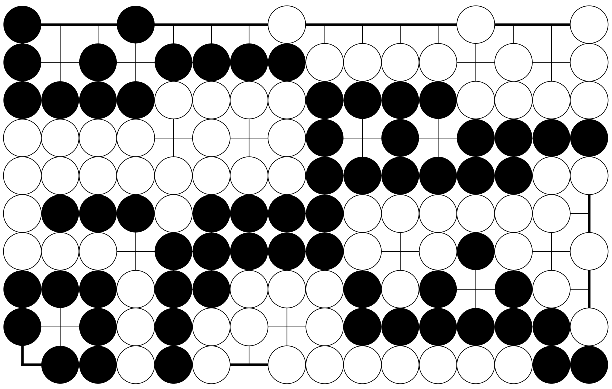
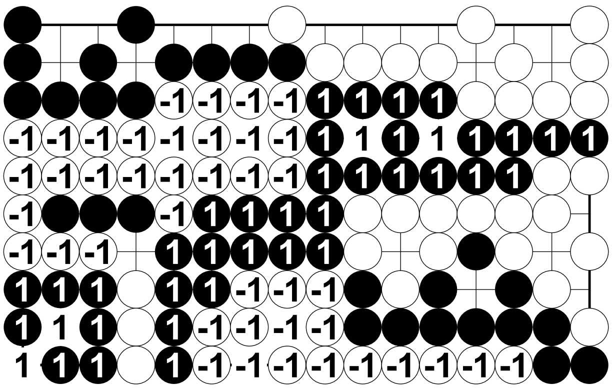
Example 9 - Komi = 0.5, Black to Move

If the komi were 0 or any other value, there would be the same global-ko-intersections. Depending on the komi, the players' roles might be swapped. If the komi is 0, then either player can assume the role of answer-forcing a cycle.

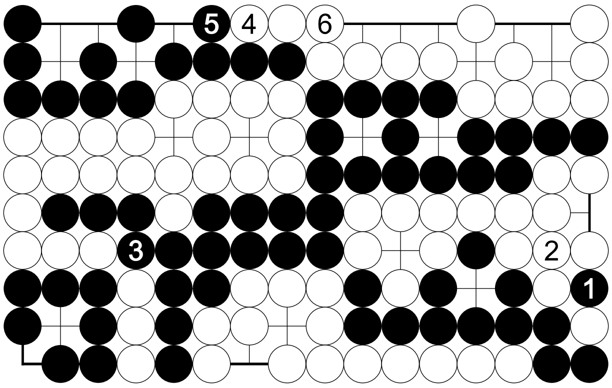
 Each of the marked intersections is a global-ko-intersection. (Note: Each is also a basic-ko-intersection and a local-ko-intersection.)	 3 pass, 4 pass. Variation 1	 Continuation. 5 is allowed by the fixed-ko-rule and does not end the game by the cycle-end-rule. 6 invokes the cycle-end-rule. The score is -0.5. White prevents Black's win. The interesting cycle is from 1 to 6. Black moves first in it from the current-position. Move 6 creates the current-position. Each of the marked intersections is in the cycle-set.
 3 pass. Variation 2	 6 pass. Continuation. 6 invokes the cycle-end-rule. The score is -0.5.	White prevents Black's win. The interesting cycle is from 1 to 5. Black moves first in it from the current-position. Move 5 creates the current-position. Each of the marked intersections is in the cycle-set.
White prevents Black's win. Black can answer-force one of the interesting cycles in Variations 1 or 2. Hence each of the marked intersections is a global-ko-intersection.		

Example 10 - Komi = -0.5, Black to Move

Quadruple ko stones and the position's topic were discovered by Matti Siivola.

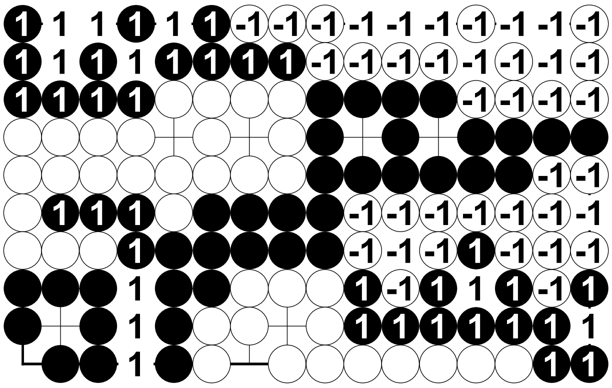
	 The area on the uninteresting rest of the board is -1.

Example 10 - Scoring Positions

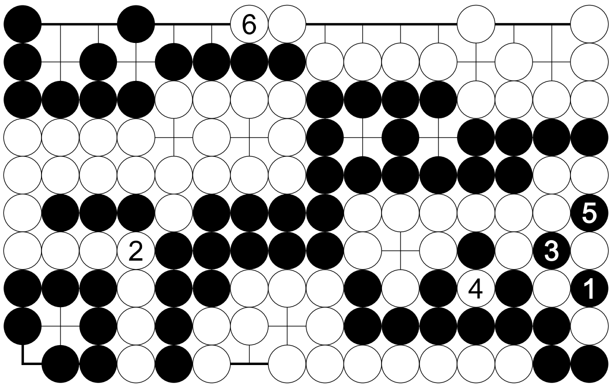


7 pass, 8 pass, 9 pass.

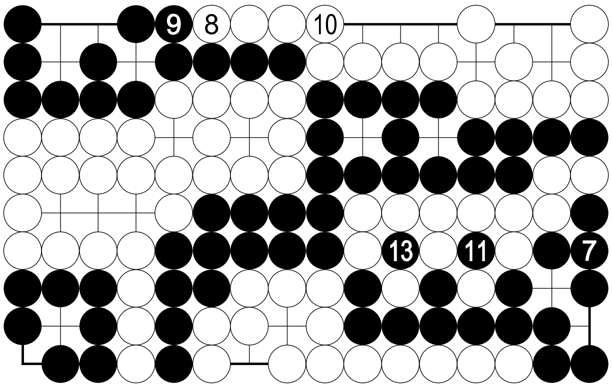
Variation 1. After 6, playing in the triple ko is uninteresting under the default restriction rules.



Scoring position after Variation 1.
Score = 15 + 18 + 7 + 0.5 - 17 - 22 - 1 = 40.5 - 40 = 0.5.

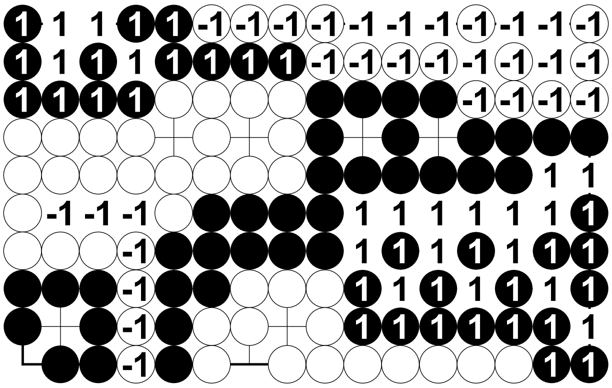


Variation 2.

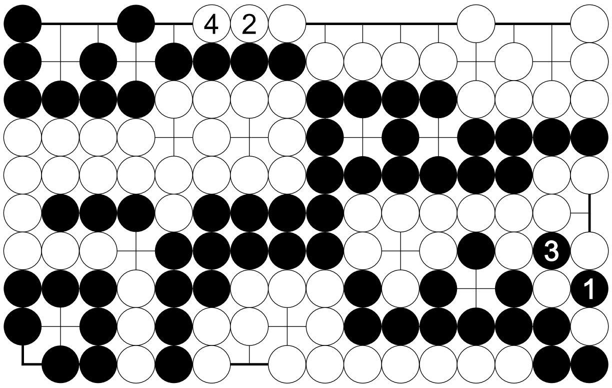


12 pass, 14 pass, 15 pass, 16 pass.

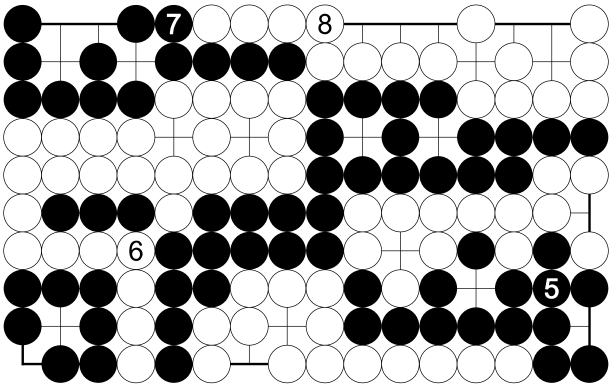
(continuation)



Scoring position after Variation 2.
Score = 32 + 17 + 0.5 - 23 - 7 - 1 = 49.5 - 31 = 18.5.

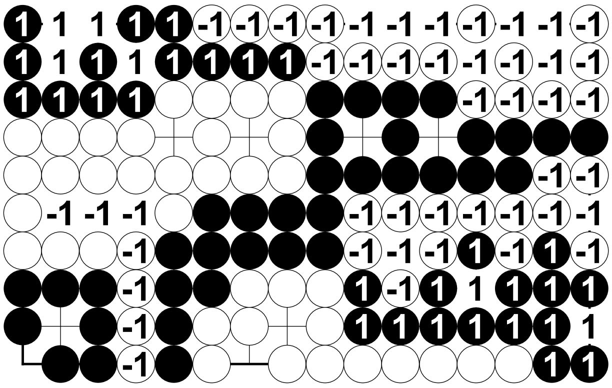


Variation 3. After 8, playing in the triple ko is uninteresting under the default restriction rules.

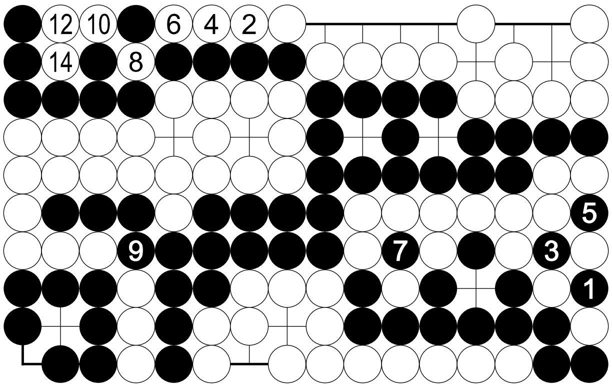


9 pass, 10 pass, 11 pass.

(continuation)

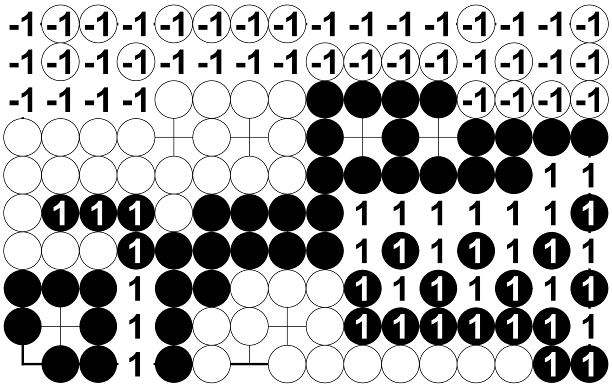


Scoring position after Variation 3.
Score = 17 + 17 + 0.5 - 15 - 23 - 7 - 1 = 34.5 - 46 = -11.5.

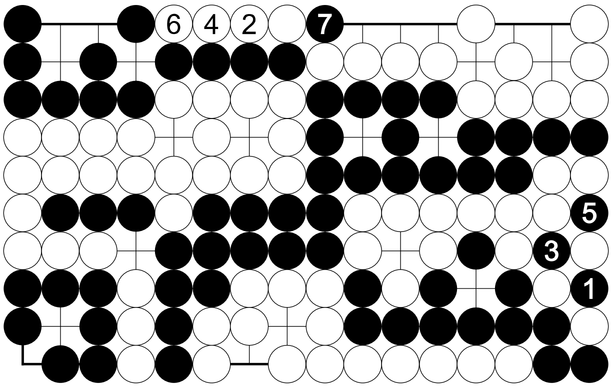


11 pass, 13 pass, 15 pass, 16 pass,
17 pass.

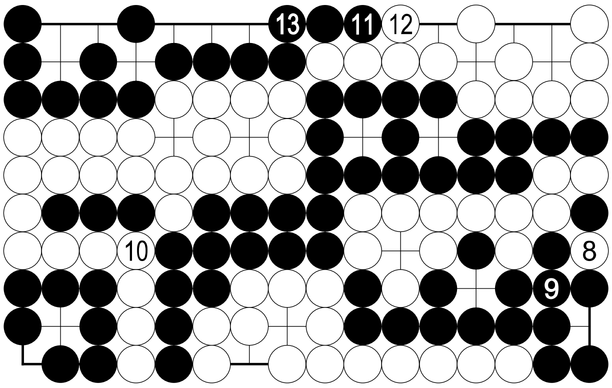
Variation 4. Move 9 capturing 8 would be answered by 12.



Scoring position after Variation 4.
Score = 32 + 7 + 0.5 - 40 - 1 = 39.5 - 41 = -1.5.

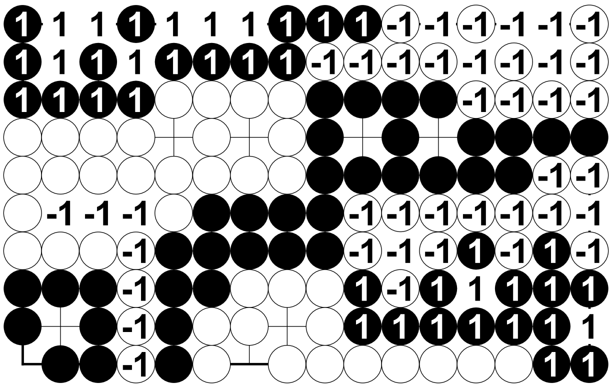


Variation 5. After 13, playing in the triple ko is uninteresting under the default restriction rules.

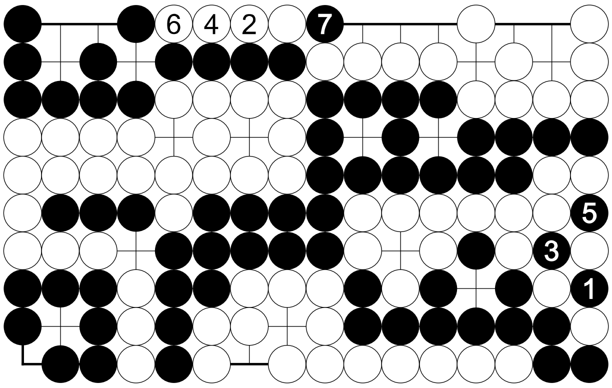


14 pass, 15 pass, 16 pass.

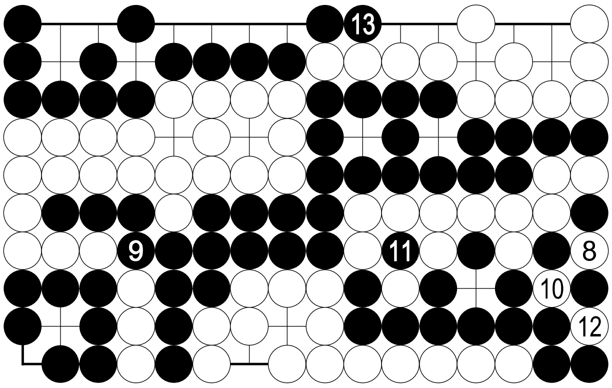
(continuation)



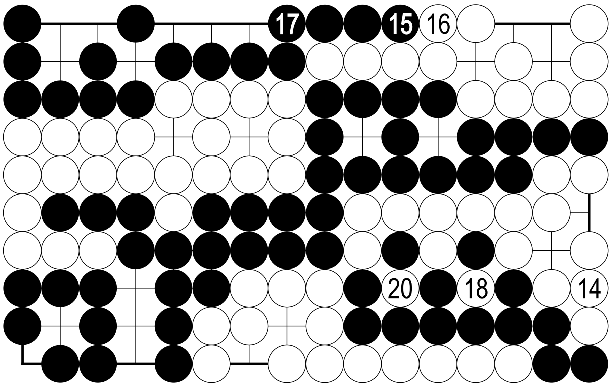
Scoring position after Variation 5.
Score = 17 + 22 + 0.5 - 15 - 18 - 7 - 1 = 39.5 - 41 = -1.5.



Variation 6.

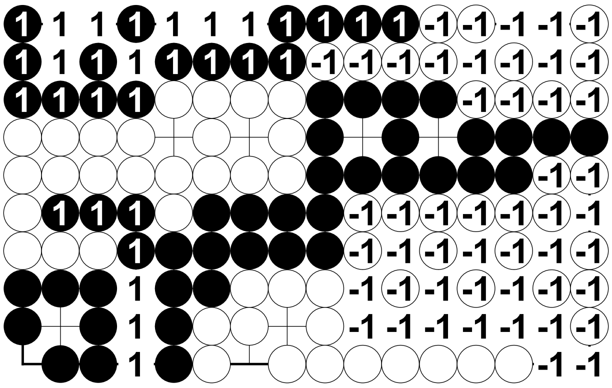


(continuation)

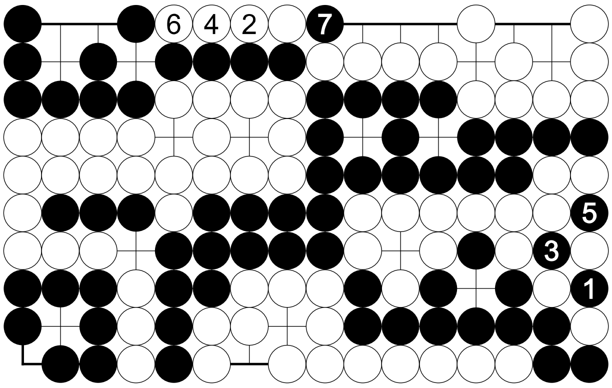


19 pass, 21 pass, 22 pass, 23 pass.

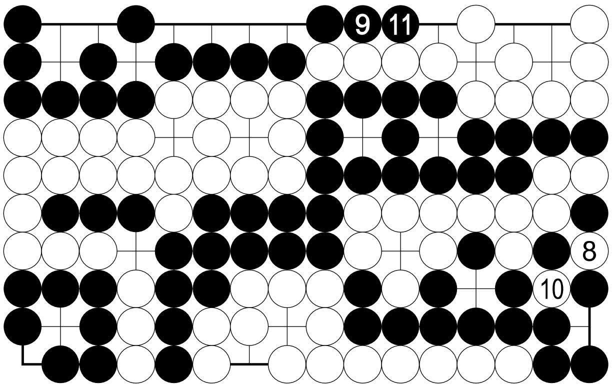
(continuation)



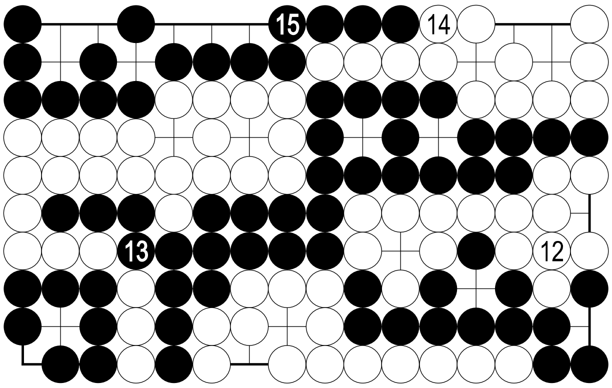
Scoring position after Variation 6.
Score = 23 + 7 + 0.5 - 32 - 17 - 1 = 30.5 - 50 = -19.5.



Variation 7. After 15, playing in the triple ko is uninteresting under the default restriction rules.

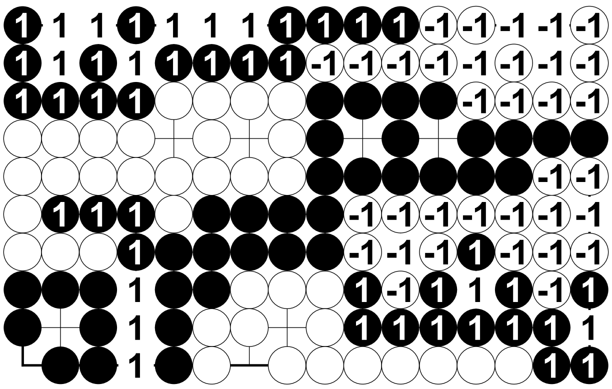


(continuation)

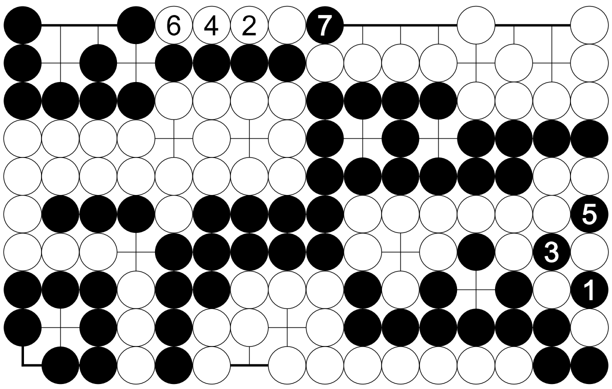


16 pass, 17 pass, 18 pass.

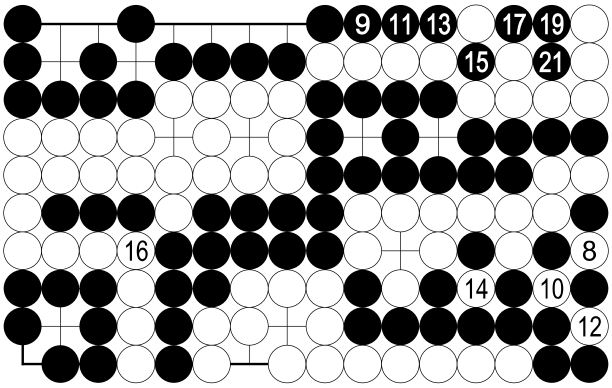
(continuation)



Scoring position after Variation 7.
Score = 15 + 23 + 7 + 0.5 - 17 - 17 - 1 = 45.5 - 35 = 10.5.

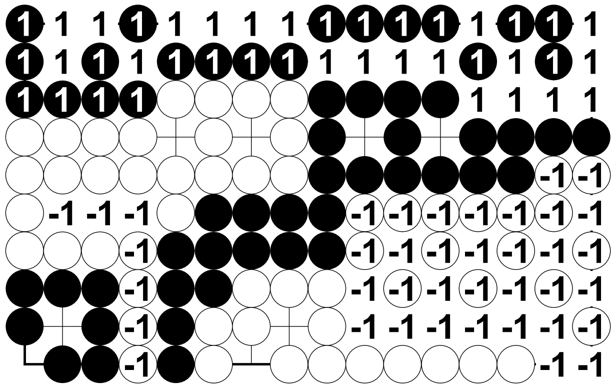


Variation 8.



(18) pass, (20) pass, (22) pass, ❷❸ pass, (24) pass.

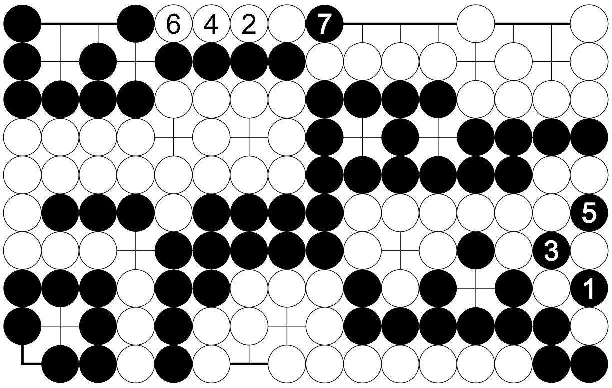
Continuation. Move 16 capturing 15 would be answered by 19.

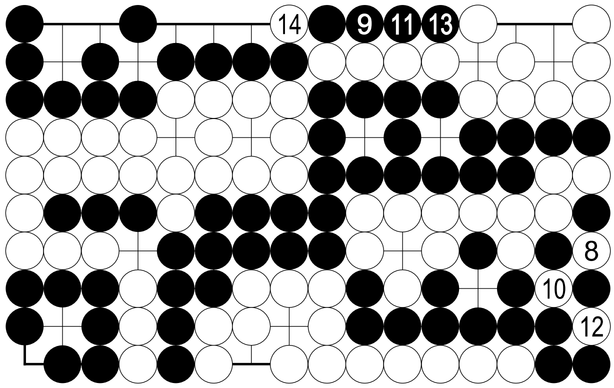


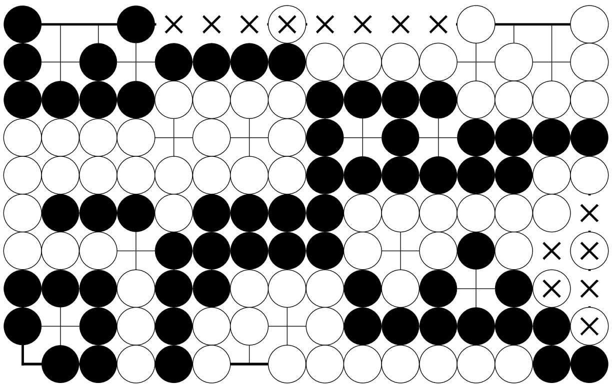
Scoring position after Variation 8.
Score = 40 + 0.5 - 32 - 7 - 1 = 40.5 - 40 = 0.5.

Example 10 - The Quadruple Ko Stones Cycle

The cycle starts from the current-position. Move 14 creates the current-position.







Each of the marked intersections is a global-ko-intersection.

Notes: 1) Probably none of the marked intersections is a local-ko-intersection. This should be supported by careful analysis though. 2) For the komi range -0.5 to -2, each of the marked intersections is a global-ko-intersection. 3) If the komi is -2.5 or smaller, then White cannot prevent Black's win and none of the marked intersections is a global-ko-intersection. 4) If the komi is 0 or greater, then White can prevent Black's win by choosing move 2 in Variation 1 while Black cannot answer-force the cycle; none of the marked intersections is a global-ko-intersection.

Example 10 - Decisions Creating the Cycle

Move 1: Black cannot force his win (i.e., White does prevent it) but he can contribute to the cycle.

Move 2: White does prevent Black's win: 1) White does not choose move 2 in Variation 1 because then Black would win. 2) White does not choose move 2 in Variation 2 because then Black would win. 3) White chooses move 2 of the cycle, see below.

Move 3: Black cannot force his win but he can contribute to the cycle.

Moves 4+6+8+10: White does prevent Black's win: 1) White does not choose other moves: obvious.

2) White chooses moves 4+6+8+10 of the cycle, see below.

Move 5: Black 5 in Variation 3 does not force Black's win. Therefore Black contributes to the cycle.

Move 7: Black 7 in Variation 4 does not force Black's win. Therefore Black contributes to the cycle.

Move 9: 1) Black 9 in Variation 5 does not force Black's win. 2) Black 9 in Variation 6 does not force Black's win. 3) Therefore Black contributes to the cycle.

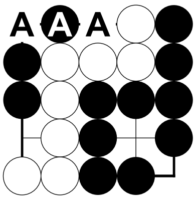
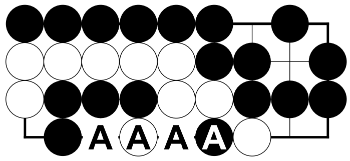
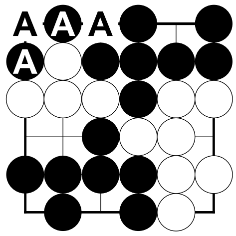
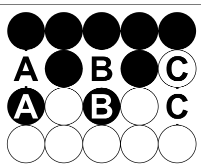
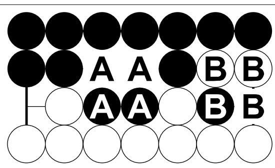
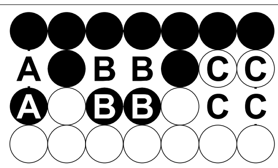
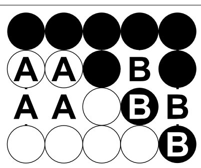
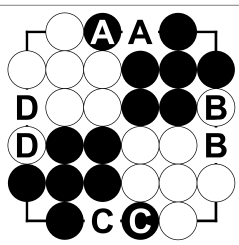
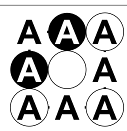
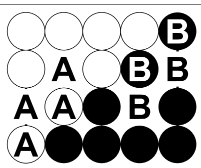
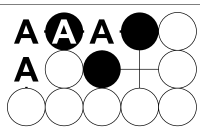
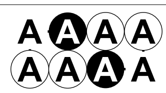
Moves 11+13: Black cannot force his win but he can contribute to the cycle.

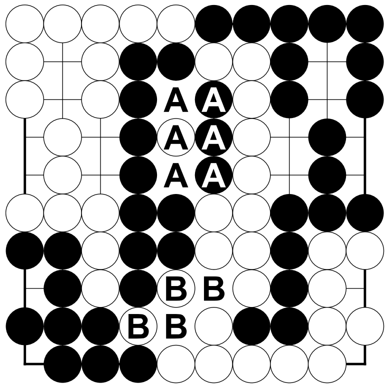
Move 12: White does prevent Black's win: 1) White does not choose move 12 in Variation 7 because then Black would win. 2) White chooses move 12 of the cycle, see later moves.

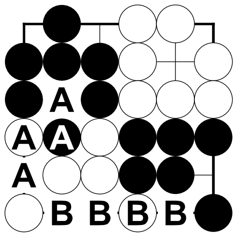
Move 14: White does prevent Black's win: 1) White does not choose move 14 in Variation 8 because then Black would win. 2) White chooses move 14 of the cycle. This invokes the cycle-end-rule. Black has now answer-forced the cycle.

Examples of Ko

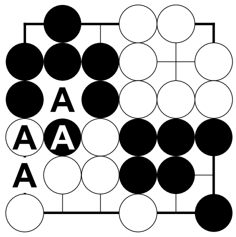
In each example, all kos in the current-position are denoted. All intersections of the same ko carry the same letter. So different letters indicate different kos.

		
 Although a triple ko has only two basic-kos at any time, the name was chosen well: There are three kos.		
		
		

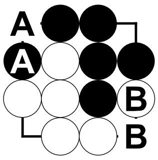


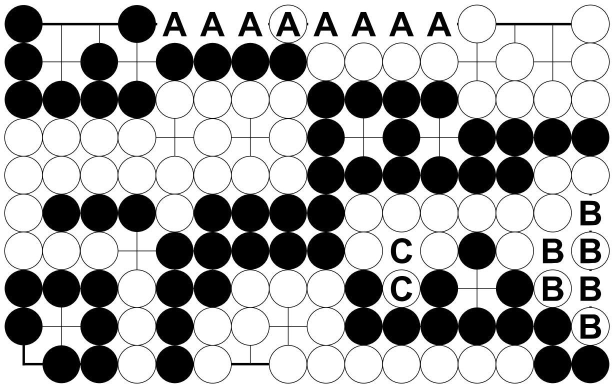


Komi = 14.5, Black to move, Territory Scoring

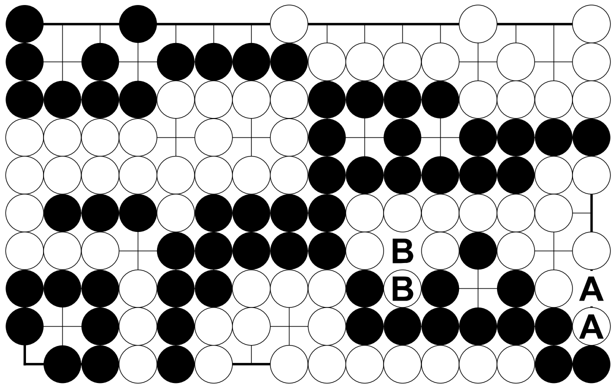


Komi = 16, Black to move, Area Scoring





Komi = -0.5, Black to move



Komi = 0, Black to move

Changes Log

Version 7b:

- correct typos in three diagrams
- clarify wording of local-, global-ko-intersection while not changing the intended contents
- clarify wording elsewhere

Version 7a:

- correct typos and other tiny mistakes
- replace declaration of history-bans by definition
- correct Examples 27+28 on local-ko-intersection
- clarify wording of (answer-)strategy, answer-force while not changing the intended contents

Version 7:

- first published version