This is the draft Chapter 6 of my planned book, *The Chess Memory Palace.* Previous draft chapters can be found here:

- Chapter 1 (*Picture Notation, A Mnemonic System for Chess*) and the Appendix (*Picture Words for all 64 Squares*) at

  https://johnden.org/picturenotation

- Chapter 2 (*Essential Memory Techniques*) at

  https://johnden.org/papers/essentialmemorytechniques.pdf

- Chapter 3 (*Memory Palace Architecture*) at

  https://johnden.org/papers/tcmp-chapter3.pdf

- Chapter 4 (*Example Palace: The Schliemann Transit Line*) at

  https://johnden.org/papers/tcmp-chapter4.pdf

- Chapter 5 (*Example Palace: The Spanish Exchange Airport*) at

  https://johnden.org/papers/tcmp-chapter5.pdf

- Chapter 7 (*Miscellanea*) at

  https://johnden.org/papers/tcmp_chapter7.pdf

Please ignore the broken references to other chapters. These will be fixed in the final version.

John Holden, November 2022

Contents

Bonus: Memorising Endgames

There are few things more tragic than playing a strong opening, a brilliant middlegame attack, and then having the win evaporate with one wrong move in the endgame.

GM Garry Kasparov

I have called this chapter a "bonus" because I see the main use of *The Chess Memory Palace* method to be memorising openings. If you learn your opening repertoire in memory palaces, you can expect to use them every game, whereas theoretical endgames are quite rare. Endgame memory palaces are also trickier to use: you need to navigate to the starting position by yourself, many of them are a complex shape, and sometimes you need to "relabel the coordinates" on the board to deal with reflections.

On the other hand, with correct use of an endgame memory palace, you can be assured of playing these endgames perfectly. And endgame memory palaces do have one advantage over opening memory palaces: with an opening, it is not enough to learn the moves, you also need to study typical plans for where the game will go next (see Chapter **??**) – but with an endgame, you actually can build a memory palace without understanding the moves. It will take you to victory, whether you are a grandmaster or a beginner! So, if you are a true devotee of *The Chess Memory Palace* method, read on.

In the first half of this chapter, we adapt picture notation for endgames, and see how to deal with reflections. In the second half, I present six tree

diagrams, ready for you to memorise. Some of these use advanced techniques which I will introduce as they arise.

Candidate pieces revisited

It is possible to continue using the *start from the back, break ties starting from the a-file* syllables rule for choosing candidate pieces, just as we learned in Chapter **??**. But this would be confusing when we deal with reflections.

So instead, in endgame memory palaces we assign each piece a number of syllables according to its value. We use one-syllable picture words for a player's most valuable remaining piece (always the king), two-syllable picture words for a player's second-most valuable remaining piece, three-syllable picture words for a player's third-most valuable remaining piece, and four-syllable picture words for a player's fourth-most valuable remaining piece.*

As a reminder, the king is the most valuable piece – because its loss ends the game – followed by the queen, rook, bishop, knight, then pawn.

If a player has a king and queen, for example, every king move is a one-syllable picture word, while every queen move is a two-syllable picture word. It does not matter whether one or both pieces can move to the target square.

In the position below, one of the lines (from Figure 7) continues *wolf robber*, *chick chariot*, *hulk mask*.

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*If either player has more than four remaining pieces, there will be too many branches for a memory palace to be feasible.
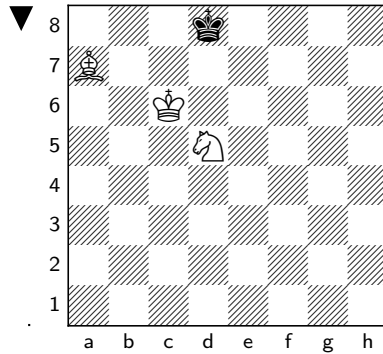
Black has only a king, so all her moves are one-syllable picture words: *wolf* (...Ke8), *chick* (...Kf7), and *hulk* (...Ke7). In order of piece value, White still has a king (one-syllable picture words), a bishop (two-syllable), and a knight (three-syllable). Therefore *robber*, two syllables, is Bd4; *chariot*, three syllables, is Nf4; and *mask*, one-syllable, is Kc7. So the sequence of moves is ...Ke8 Bd4, ...Kf7 Nf4, ...Ke7 Kc7.

Let's see a second example, where both sides still have more than one piece. In the position below, part way through Figure 8, the next two composite images are *raft giraffe* and *lobster astronaut*.
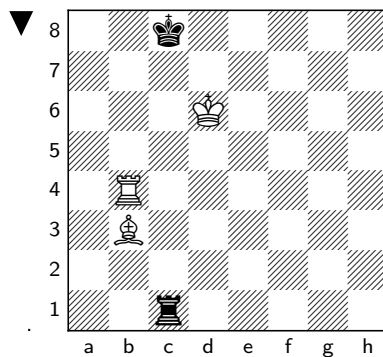
Black has two pieces left, in order of value they are the king (one-syllable picture words), and the rook (two-syllable). Therefore Black's

one-syllable picture word *raft* must be a king move (...Kd8). Black's two-syllable picture word *lobster* must be a rook move (...Re1).

White has three pieces left, in order of value they are the king (one-syllable picture words as always), the rook (two-syllable), and the bishop (three-syllable). Therefore White's two-syllable picture word *giraffe* must be a rook move (Rf4). White's three-syllable picture word *astronaut* must be a bishop move (Ba4). The sequence of moves is ...Kd8 Rf4, ...Re1 Ba4.

This endgame candidate piece system works perfectly as long as all the remaining pieces of each colour are unique. In practice this has worked for every endgame memory palace I have built: any endgames with duplicated pieces – a pair of rooks or knights – have too many branches to be worth memorising in a palace. (There is no ambiguity if one player has two bishops, because the bishops can never move to the same target square. The bishops can both use the same number of syllables in their picture words. Similarly pawns normally stay in order, so there is very rarely ambiguity.)

If you do want to build an endgame memory palace where one player has a pair of rooks or knights, you have two options: (1) revert to the standard *start from the back, break ties starting from the a-file* rule for candidate pieces, or (2) distinguish the duplicated pieces. For example, one knight would always use two-syllable picture words, and the second knight would always use three-syllable picture words.

Specified piece moves

The key to a good endgame memory palace is to keep it compact by minimising branching. Sometimes you can do this just by choosing variations carefully. But often we need to be smarter about how we identify moves.

In the position below, following Figure 3, White is triangulating the Queen towards a5 to put Black in zugzwang.
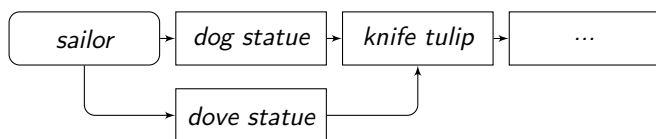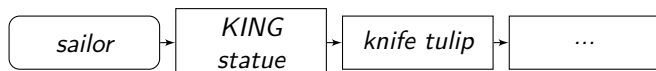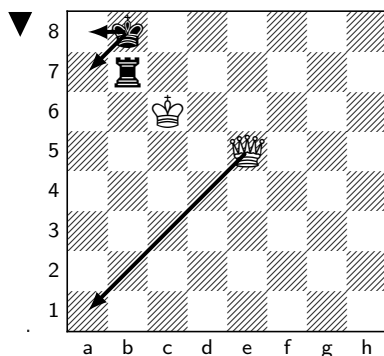
Figure 1: Naïve tree diagram: Queen v Rook

Figure 2: Simplified tree diagram: Queen v Rook

Muff (...Kc8) would be instant mate by *lava* (Qe8#), so Black plays *dog* (...Ka7) or *dove* (...Ka8). In both cases, play continues *statue* (Qa1+), then *knife tulip* (...Kb8 Qa5). We could draw a branching tree diagram like Figure 1, but this is more complicated than it needs to be. Instead, we replace *dog* and *dove* with one picture word, *KING*: see Figure 2.

The picture word *KING* is a **specified piece move**. We are specifying the piece that moves (the king), rather than the target square. *KING* means any (not instantly losing) move by the king.

I write *KING* in uppercase as a reminder of its special meaning, but we memorise it as normal using the techniques of Chapter **??**. Imagine a medieval king like King Henry VIII.

Specified piece moves can happen with any piece. Figure 6 contains a specified piece move with the rook. In the position below, White has just challenged Black's rook for the b-file, so Black must move her rook anywhere on the first rank, followed by White's *snake* (Kb7) and then Black's *Santa* (...Rb1+).
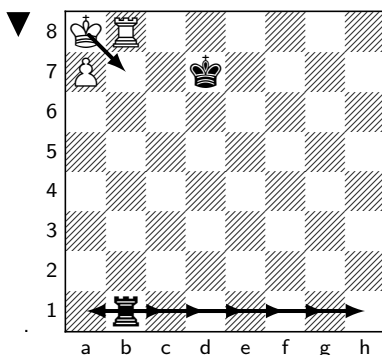
To cover all seven options (...Ra1, ...Rc1, ...Rd1, all the way to ...Rh1), a memory palace would have to split into seven branches! It's much easier to remember one composite image, "a *ROOK* stomping on a *snake*". This means any rook move, followed by Kb7. In practice this means any rook move *along the first rank*: your opponent will never play the rook up the b-file, because that is an instant loss. And if she did, *snake* (Kb7) would be illegal anyway, so you can't play it.

For *ROOK*, I imagine an anthropomorphic castle tower, much like the chess piece. You could imagine the corvid bird called "rook" if you prefer.

Ladders revisited

In Chapter **??** I introduced **ladders** to indicate an option for the memory palace user. For example, in Figure **??** one location containing a *lion* and a *robber* was connected by a ladder to a second location containing a *lion* and a *crab*. This means you can respond to *lion* by playing *robber* or by playing *crab* – whichever you prefer.

In an endgame memory palace, a ladder has a different meaning. Instead of giving you a choice of moves, a ladder means you should continue

through the first location if you can – but, if the move is impossible, you should climb the ladder to the second location.

For example, suppose you are following Figure 6, when you reach *Santa muff*. (As before, locations with a ladder are shown by a grey box. Ladders are shown by a dashed arrow.) Your opponent plays *Santa* (...Rb1) as expected. You should now play *muff* (Kc8). But, if you cannot (because Black has a king on d7), then you should follow the ladder to the location containing *Santa dish*, and therefore play *dish* (Ka6).

Ladders are very useful to condense our memory palaces into smaller sizes. In this case, we could deal with two slightly different starting positions in a single palace. Figure 8 takes this to an extreme.

Horizontal reflections

One of annoying things about learning endgames in the traditional way is the need to practise in different orientations. If you learn an endgame perfectly in the top-left corner, you may be confused when trying to execute the same technique in the top-right corner, unless you have taken double the time to train your pattern recognition in both directions. This is even more worse when there are no pawns on the board, as each position can occur in eight different orientations (horizontal, vertical, and diagonal reflections), not to mention reversed colours!

The Chess Memory Palace method conveniently avoids this problem, because the same memory palace will work for every orientation. You just need some mental agility to relabel the files and ranks.

Let's begin with the simple case of a horizontal reflection, following Figure 6.
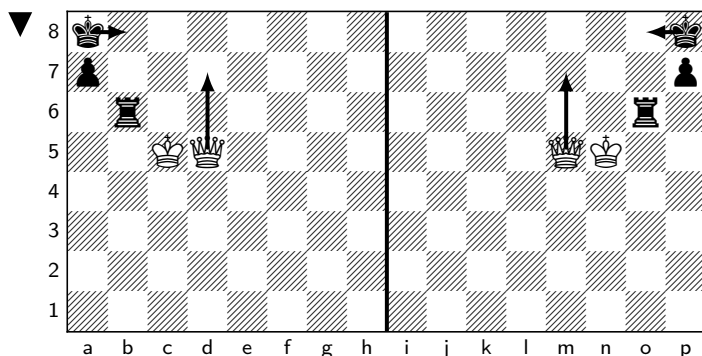
The diagram on the left is the **base orientation**, drawn from White's perspective with the main action in the top-left corner. The diagram on the right is the same position, reflected horizontally.

Notice how I labelled the files on the right-hand board backwards, from h to a. If you are playing on a physical board, forget the real coordinates except to record the moves on your score sheet. If you are playing online, forget the real coordinates completely. Keep the new labels in your mind, and then continue using your memory palace as normal.

White has two pieces left. In order of value, they are (1) the king, and (2) the queen. So White king moves are identified by one-syllable picture words, and queen moves by two-syllable picture words. Black has two pieces left: (1) the king, and (2) the rook. So Black king moves are identified by one-syllable picture words, and rook moves by two-syllable picture words.

You expect your opponent to begin *knife*, when you will reply *sparkler*. If you are playing the left-hand board, the moves are ...Kb8 and Qd7. If you are playing the right-hand board, the moves *in your head* are ...Kb8 and Qd7, but on the scoresheet you must write ...Kg8 and Qe7.

Playing the endgame in a horizontal reflection is just as easy as the base orientation, once you have got your head around the flipped file labels.
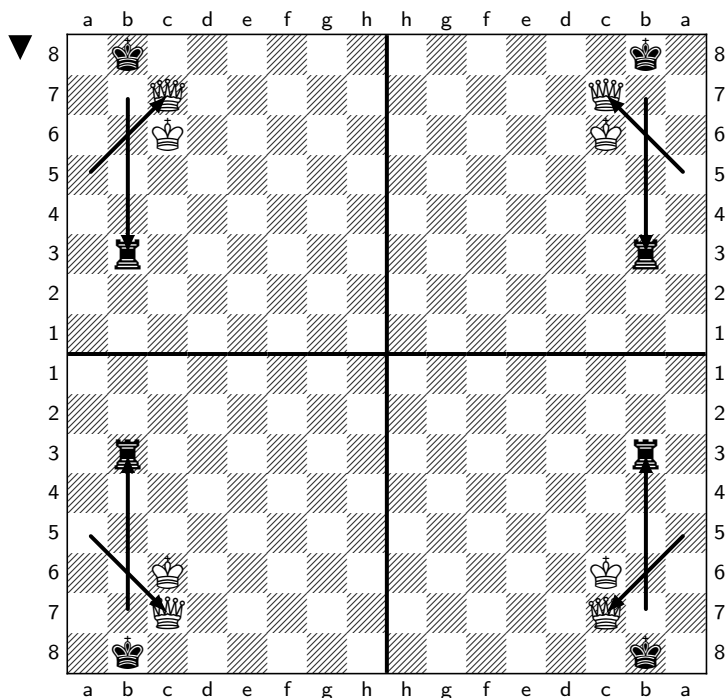
Vertical reflections

In the endgame, pawns are the only pieces that have a set direction of movement. So once all the pawns are gone, vertical (and diagonal) reflections become possible.

In the case of a horizontal reflection, we mentally relabelled the files from h to a. In the case of a vertical reflection, we mentally relabel the ranks from 8 to 1. If there is a horizontal *and* vertical reflection (equivalent to a 180 degree rotation), we mentally relabel both the files and the ranks.

See the diagram below, which arises after *knife tulip* in Figure 3.
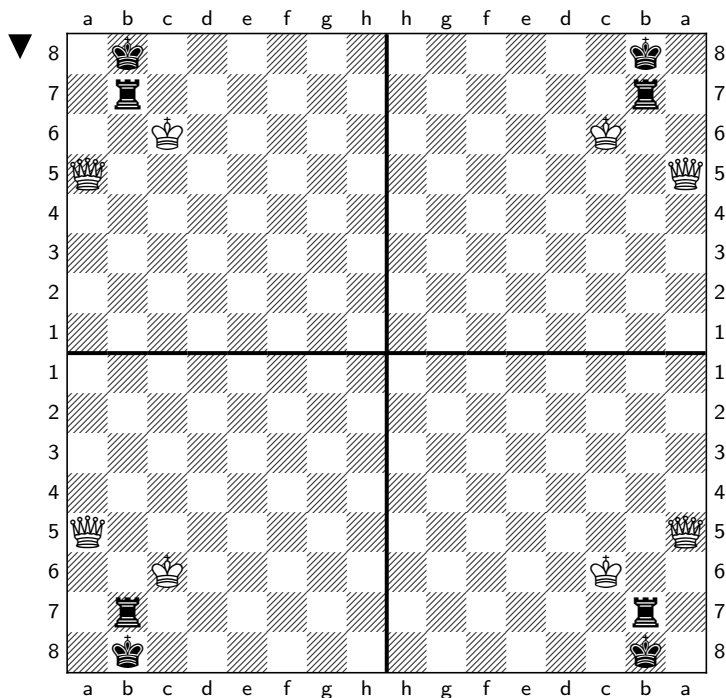

Here Black should play *snowman* (...Rb3 in the base orientation) or *Santa* (...Rb1). Let's say your opponent plays *snowman*. You should respond *magpie* (Qc7+). Remember that you have relabelled the coordinates!

Diagonal reflections

For diagonal reflections, the board is essentially oriented left-right rather than up-down. When you reach the endgame position, take a moment to pause and work out what orientation you are facing, then mentally relabel the files and ranks. The key to diagonal reflections is to label the horizontal rows as files, a to h or h to a, and the vertical columns as ranks, from 1 to 8 or 8 to 1. This is worth practising once or twice at home before you do it in the pressure of a tournament.
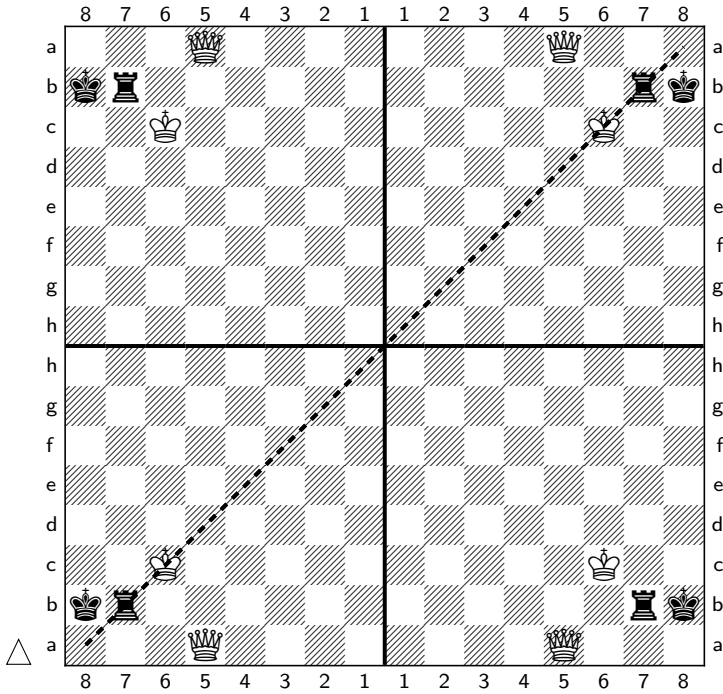
Note that the diagram above no longer contains the base orientation, because all four boards have been reflected diagonally along the dashed line.

This time, instead of playing *snowman*, let's say your opponent plays *Santa* (...Rb1). Your reply is *perfume* (Qe8+). Again, don't forget that you have relabelled the coordinates!
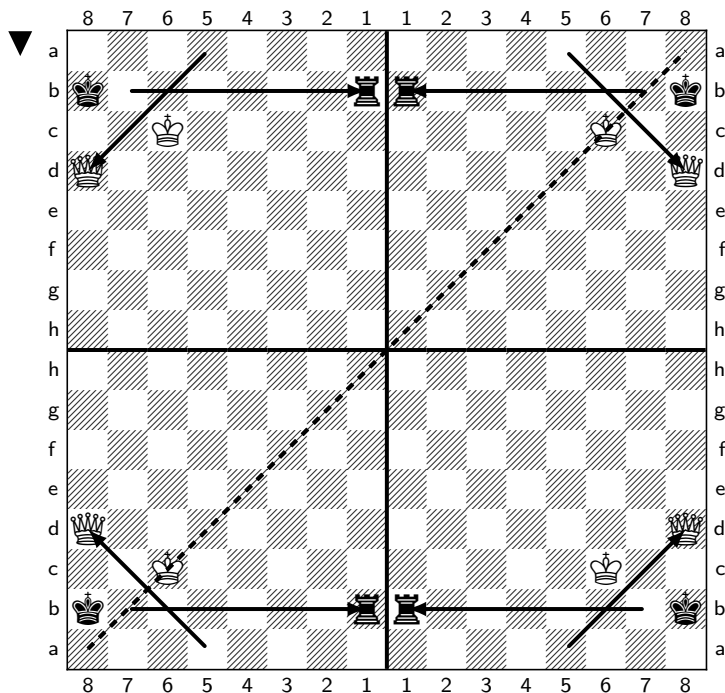
To recap, if you are playing the bottom-left board, your opponent will see ...Rh2 and Qa4+. You must write ...Rh2 and Qa4+ on your scoresheet. But in your head you are not using the real coordinates. In your head, you have played *Santa perfume* (...Rb1, Qd8+), on a relabelled board.

Reversed colours

I have drawn the diagrams with White pressing for the win. What if you are trying to win with the Black pieces?

This is easy. Just use the same memory palace, and imagine the colours are swapped. Imagine yourself to have the white pieces and your opponent to have the black pieces.

For example, let's play Black queen versus White rook and rook's pawn, following Figure 5.
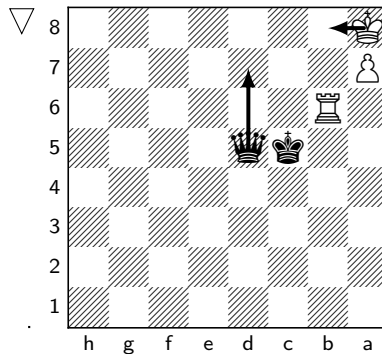
This diagram is looking from Black's point of view, just as you would see it at the board. White's pawn is on its starting square. But the ranks are relabelled from 1 to 8, as if rank 1 were your back rank, and rank 8 your opponent's back rank. The easiest way to think about this is to imagine the colours are reversed: imagine you are playing White, on a horizontally-reflected board.

After playing *barrel* (Qd5+) to reach the base position, your opponent plays *knife* (Kb8). As we have already seen, you should respond with the zugzwang *sparkler* (Qd7). On your scoresheet, write Kb1 and ...Qd2.

Example endgame tree diagrams

I will now present six ready-made endgame tree diagrams. Unlike Chapters **??** and **??**, I have not written out detailed stories for each of the composite images. Memory palaces are most effective when you choose settings and images that are personal to you. So if you want to memorise these endgames, for each tree diagram you need to choose a setting, then choose a location for each composite image, and finally visualise the scenes one by one (as explained in Chapter **??**).

In all cases I have drawn the position from White's point of view, with the main action in the top-left quadrant. This will help you remember which orientation is the base orientation, when mentally reflecting the coordinates during a game.

The tree diagrams end where there is a simple tactic to checkmate or win a piece. There is no point memorising the final couple of moves that are easy to find. Similarly, if your opponent deviates from the tree diagram before the end, you have an immediate win.

Most of the tree diagrams have a **core repertoire** of boxes drawn with solid borders, then additional boxes with dotted borders. I recommend you memorise the core repertoire. The additional boxes are optional: memorise them if you are not confident in winning from the end of the core repertoire. The additional boxes take one more step towards checkmate (or the win of a piece), at the cost of having more to memorise.

For each example tree diagram, I will say how far the core and optional locations take you. The letters DTZ stand for "distance to zero". For our purposes, this means the number of half-moves before a checkmate, decisive capture, or decisive pawn promotion.

For example, the core repertoire of Figure 3 takes you to DTZ6. After Black's next move, there will be six half-moves before White captures Black's rook.
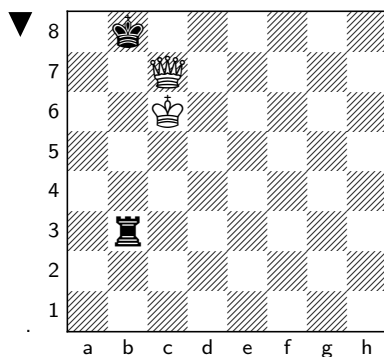
After *snowman magpie* – the last box in the core repertoire – you will reach the position above. The core repertoire takes you to DTZ6, so after your opponent's next move (…Ka8) there must be a three-move tactic to win the rook. There are a few options, including Qg7 Rb1, Qg8+ Ka7, Qh7+ Ka8, Qxb1.

If you like, you can memorise the additional location *dove peacock* (…Ka8, Qg7). This takes you one move further, to DTZ4. Now you need

only find a two-move tactic at the board, such as Qg8+ Ka7, Qh7+ Ka8, Qxb1.

Queen v Rook: Philidor position
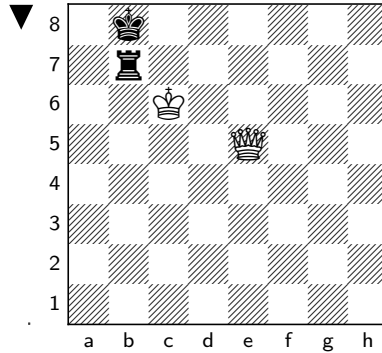
Our first example tree diagram is the critical Philidor position in the queen versus rook endgame, when White has backed Black into a corner. Figure 3 shows how to win.

The first location contains a single picture word, *lily*, to remind you that White's queen starts on e5.

The second location contains a specified piece move, *KING*. This indicates ...Ka8 or ...Ka7. In the unlikely event that your opponent blunders mate-in-one with ...Kc8, I assume you will notice and play Qe8#.

If you memorise the core repertoire (the boxes with a solid border), the repertoire will take you to DTZ6. The additional locations (the boxes with a dotted border) take you to DTZ4.
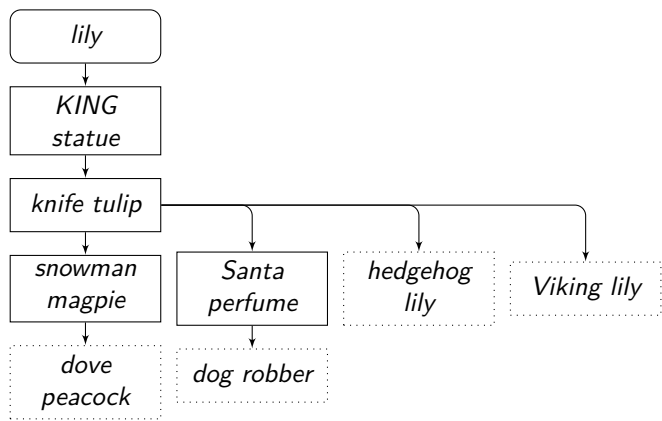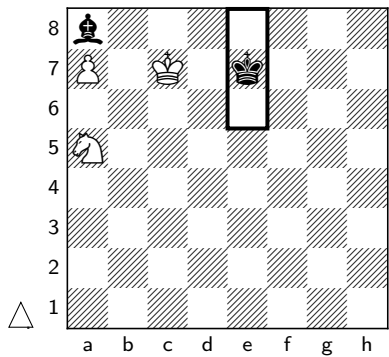
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          ┌──────────────┐
          │     lily      │
          └──────┬───────┘
                 │
          ┌──────▼───────┐
          │    KING       │
          │   statue      │
          └──────┬───────┘
                 │
          ┌──────▼───────┐
          │  knife tulip  │────────┬────────────┬────────────┐
          └──────┬───────┘        │            │            │
                 │                 │            │            │
       ┌─────────▼──────┐  ┌──────▼─────┐ ┌────▼──────┐ ┌───▼────────┐
       │   snowman       │  │   Santa    │ │ hedgehog  │ │ Viking lily │
       │   magpie        │  │  perfume   │ │   lily    │ │             │
       └─────────┬──────┘  └──────┬─────┘ └───────────┘ └────────────┘
                 │                 │
       ┌─────────▼──────┐  ┌──────▼─────┐
       │    dove         │  │ dog robber │
       │   peacock       │  │            │
       └────────────────┘  └────────────┘
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Figure 3: Queen v Rook, Philidor Position

Knight and a-pawn v Bishop

This is a surprisingly subtle endgame. If White plays Kb8 at the wrong moment, Black can follow in with her king to trap White's king in the corner, drawing.

See Figure 4 for the winning technique. There are three starting locations, depending on whether Black's king begins on e6, e7, or e8.

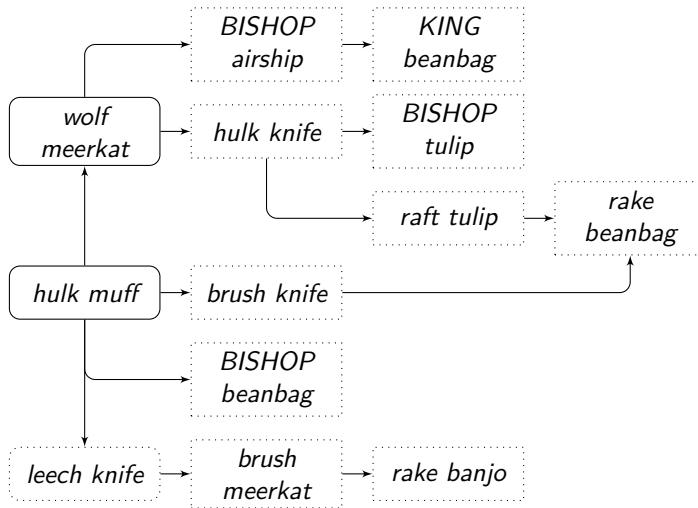The core repertoire takes you to DTZ6 (a three-move tactic to pro-

Figure 4: Knight and a-pawn v Bishop

mote or win the bishop – in other words, you can promote or capture the
bishop on your fourth move after the core repertoire ends). I recommend
learning at least the first layer of additional locations as well, because it
is not enough just to capture the bishop – you need to capture the bishop
at a time that does not get White's king stuck on a8.

Queen v Rook and a-pawn
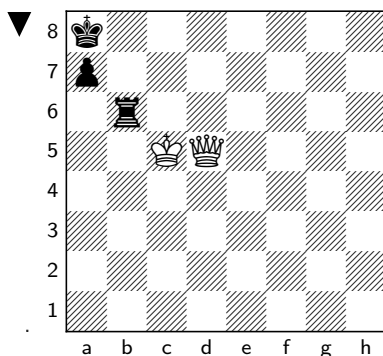
This endgame is a lot more difficult than it looks. Endgame textbooks might cover it quickly, but several of the sidelines involve long series of queen checks to win the rook, which personally I would struggle to find in time pressure. The core repertoire in Figure 5 takes you to DTZ6. The additional locations take you further, sometimes all the way to DTZ0 in lines I consider less intuitive.
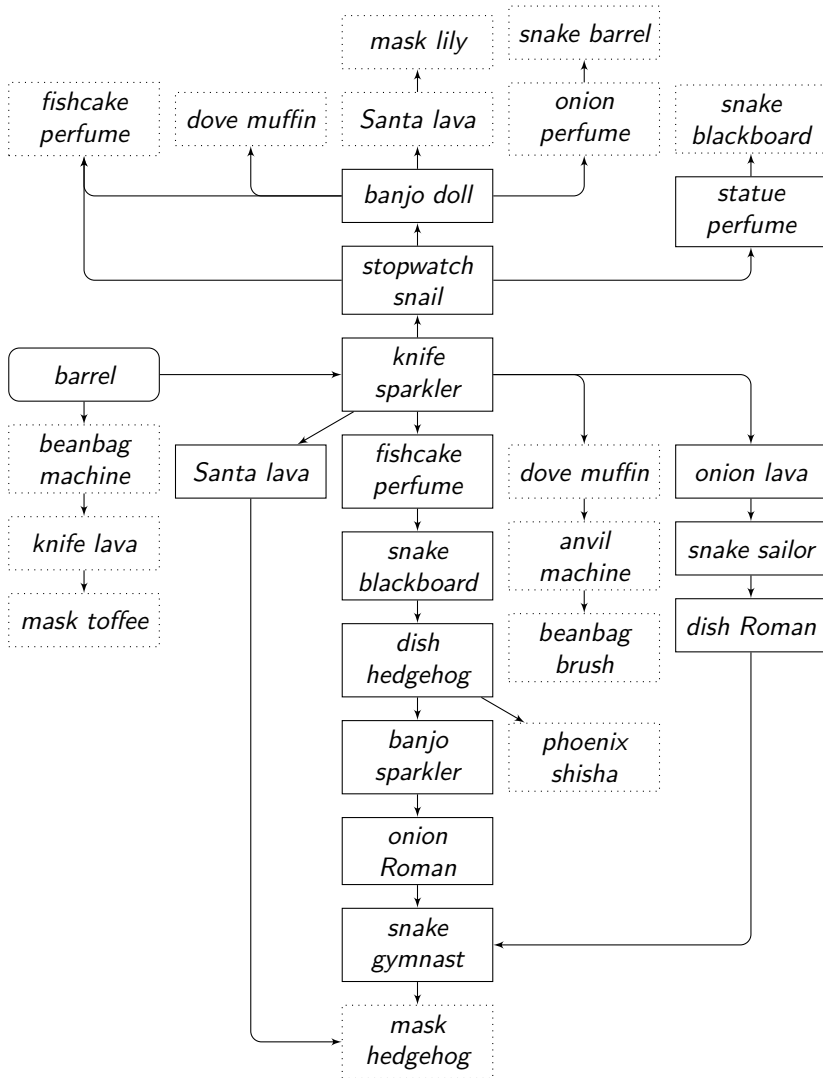
Rook and a-pawn v Rook
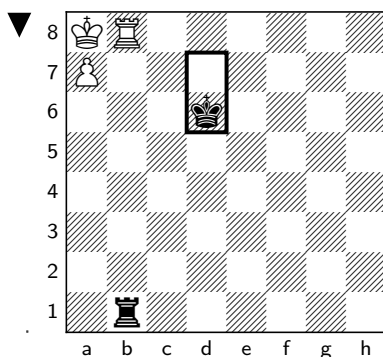
Figure 5: Queen v Rook and a-pawn (start middle-left)

This is my favourite theoretical endgame. I like how White's king crafts a different route out of the corner depending on whether Black's king takes up post at d6 or d7, and sometimes White sacrifices her rook on c6 in order to promote with check. But you don't need to know any of this if you just memorise Figure 6.

Note that the *toffee* in *match toffee* refers to a pawn promotion: a8=Q+. Recall from Chapter **??** that a pawn move to the eighth rank is just assumed to promote to a queen – there is no additional notation. At the point of promoting, White has sacrificed her rook on c6, so the pawn is her second-most valuable piece left, and uses two-syllable picture words. After it becomes a queen, it is still White's second-most valuable piece, so continues to use two-syllable picture words.

After *match toffee* (...Kxc6, a8=Q+), the position is queen versus rook. I have extended the core repertoire as far as *match muffin* at DTZ10. From here, the win is fairly straightforward: keep checking with the queen, and don't let Black's king approach the rook (for example by checking from the f-file to cut off the king from approaching the rook). If you memorise the additional locations as well, they will take you to DTZ6.

By the way, if at any time you notice Black's rook is en prise, just capture it.[†] If not, follow the repertoire.

[†]This can happen if Black has played the less-challenging *feather* (...Rh1), which will be visible to the new queen on a8, instead of *kitten* (...Rg1). Not for the only time in this chapter, I made the tree diagram smaller by using a "false transposition" – merging two lines, even though the position on the board is not identical.
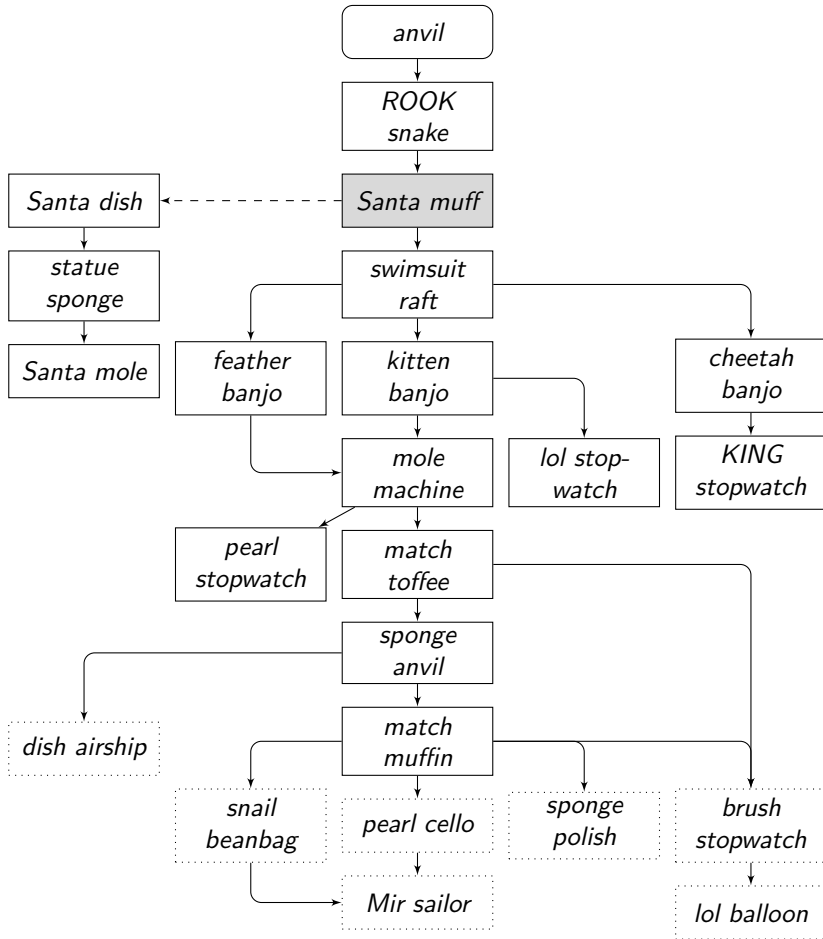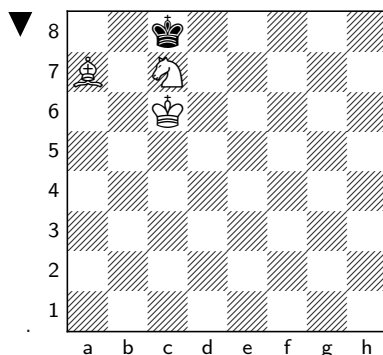
Figure 6: Rook and a-pawn v Rook

Bishop and Knight checkmate

As you force Black back towards the edge of the board, she will typically run to the corner that your bishop does not control. This tree diagram takes you from that corner to checkmate in an adjacent corner.

The core repertoire takes you to DTZ8 (mate in five after Black's next move). The additional locations take you to DTZ6 (mate in four after Black's next move).

In terms of tree diagram structure, this is the most complex repertoire to memorise in the book. To make it a little bit smaller, it contains a new technique: locations containing four picture moves. For example, *gift hulk chariot shisha* are all in one location. This means that after Black plays *gift* (...Kg8), your next three moves – whatever Black does – are *hulk chariot shisha* (Ke7 Nf4 Bf6). Memorise these as a sequence of four interacting picture words in one location.[‡]

[‡]If you don't like this, you can of course insert the picture word KING as Black's moves. *Gift hulk chariot shisha* can be split into three locations: *gift hulk, KING chariot, KING shisha*. But this requires more memory work: 3x locations and 1.5x picture words.
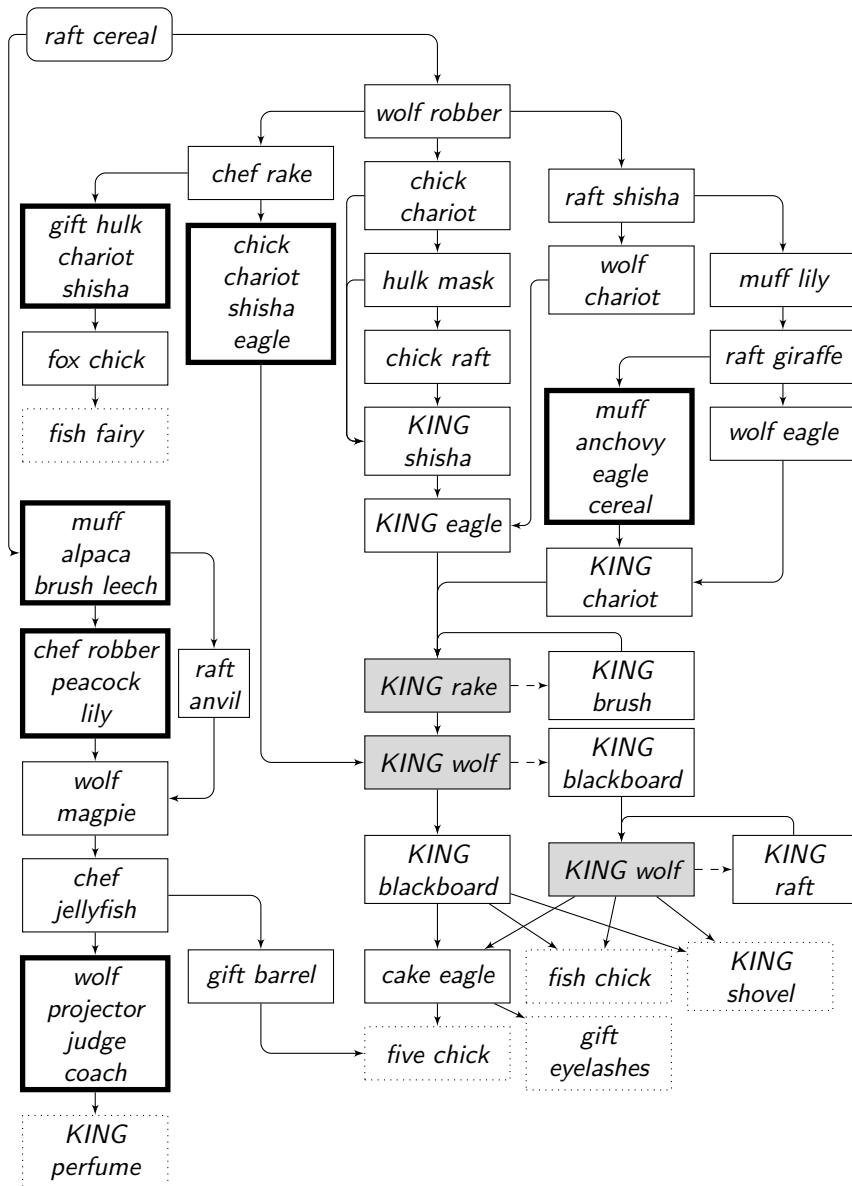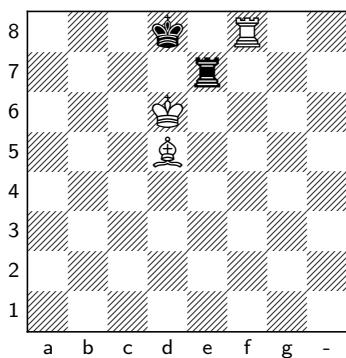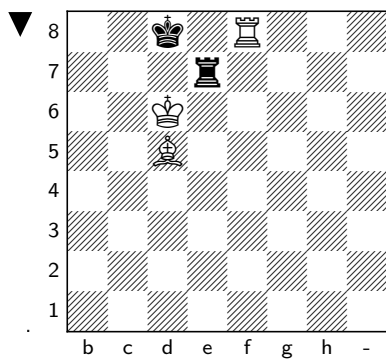
Figure 7: Bishop and Knight checkmate

Rook and Bishop v Rook: Lolli and Philidor positions

With perfect defence, rook and bishop versus rook is a draw. But it is often won in practice. If you can reach either position below, and you have memorised Figure 8, the win is yours. Figure 8 takes you to DTZ6, mate in four (or win the rook if Black throws it away).

The diagram on the left is the Lolli position. The diagram on the right is (another) Philidor position. Pay careful attention to the file labels! The Lolli diagram runs from *b* to *h*, with the last file unlabelled. The Philidor diagram runs from *a* to *g*, with the last file unlabelled.

These strange file labels serve an important purpose: we can use a single memory palace to learn both endgames. If, in the locations indicated by a grey box, you are asked to play an impossible move – a move to the non-existent a-file in the Lolli game, or a move to the non-existent h-file in the Philidor game – simply "climb the ladder" to the alternative location, then continue as normal.

Imagine you are playing out the Philidor position (right-hand diagram), and you follow your memory palace until you reach *muff Viking* (which would be followed by *dove waffle* and then *magpie eagle*). Your opponent plays *muff*, and you must respond. *Viking* is impossible, because it identifies the target square **h7**, but there is no file labelled h. So you climb the ladder to the next composite image, *muff narwhal*, then carry on as normal: after playing *narwhal* you expect your opponent to continue with *raft*, to which you will reply *giraffe*.

Alternatively, imagine you are playing out the Lolli position (left-hand diagram), and you reach *lava tiger*. *Tiger* is impossible because it identifies the target square **a7**, but you have no a-file, so instead you climb the ladder to *lava jaguar*. You play *jaguar*.

One of the arrows overlaps another when this diagram is printed on a two dimensional page. When constructing your memory palace, this will not a problem, because your memory palace will be three dimensional. For example, if you are walking along a train carriage, with *lava hedgehog* by the doors, *balloon peacock* on the seats and *lobster beanbag* by the doors at the far end, then an alternative route could take you climbing over the roof straight from *lava hedgehog* to *lobster beanbag*.
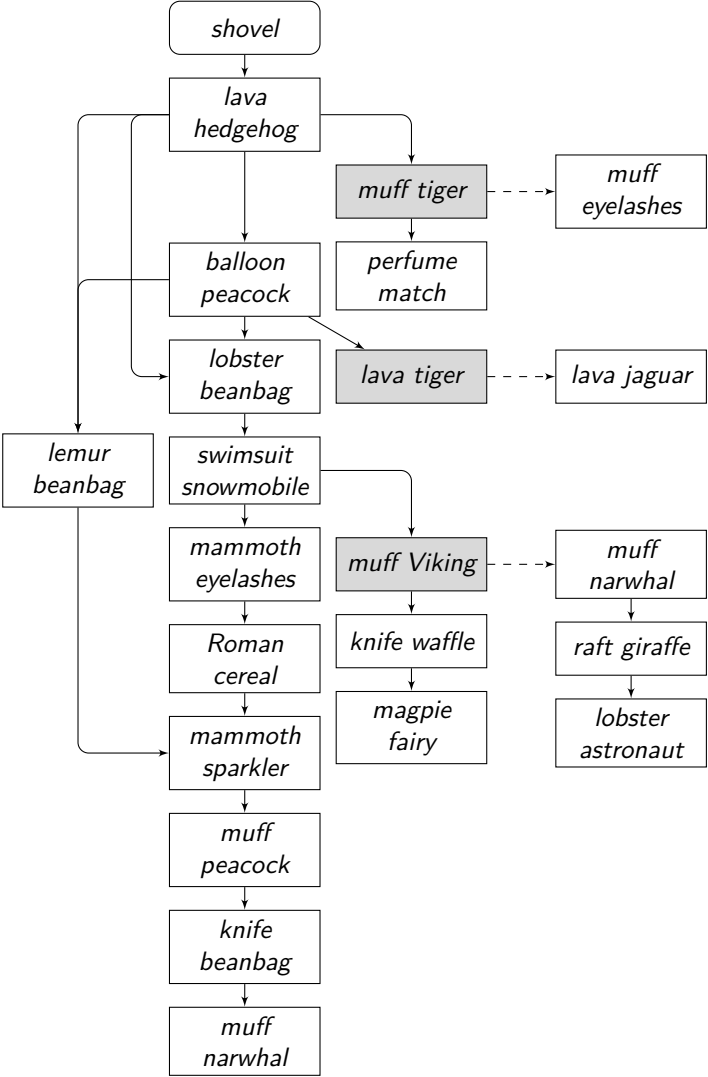
Figure 8: Rook and Bishop v Rook, Lolli and Philidor Positions

Notes

Chapter 6

1. "*There are few things*": Garry Kasparov (2007) How Life Imitates Chess. William Heinemann, page 148

2. *without understanding the moves*: Some players argue that learning, say, to checkmate with bishop and knight teaches you how the pieces work together, even if you never see the endgame at the board. I confess that I am sceptical of this. Middlegame positions are often explained by analogy to an opening ("an improved Marshall", "a similar plan to the King's Indian" and so on) but they are rarely if ever explained by analogy to a theoretical endgame ("You should move the bishop because it's similar to the bishop and knight ending").

   Incidentally there is a philosophical question about what it means to "understand" a technique. John Nunn discusses this question in his 1995 book Secrets of Minor-Piece Endings. Batsford, pages 268-272. He suggests that "understanding" is related to having a simplified logical rule that explains a mass of data, and argues that memorising a single line to defeat the defender's optimal play would not demonstrate understanding, because the defender could "throw in the occasional sub-optimal move in order to defeat such memory techniques". But what if you *can* brute-force memorise the winning moves in every variation, as taught in *The Chess Memory Palace*? It still feels to me that you would not "understand" the endgame – but you will win anyway.

3. *distinguish the duplicated pieces*: There is no rule against orienting your pieces in different directions to remember which is which! If you have two knights, point them towards each other, Carlsen style, rather than both facing forwards, Anand style. If you have two rooks, rotate one 45 degrees.

4. *set direction*: I pedantically specify "in the endgame" because kings and rooks also have a set direction of movement when it comes to castling. This is a chapter about endgames, so I assume the option to castle has long since passed.

5. *Verical reflections*: I would like to thank Ulrike Fischer for writing the *chessboard* LaTeX package, with the forethought to create it with the flexibility that makes diagrams like this possible.

6. *Queen v Rook: Philidor position*: I wanted to include a tree diagram to beat the notorious third-rank defence (White's king on d5 and queen on f7; Black's king on d8 and rook on b6). Unfortunately spending time in the tablebases only confirmed how difficult this ending is. The tree diagram would take 59 locations to reach DTZ8 in all variations – and even this is the consolidated version, sacrificing one move from the quickest path in order to prune a section with particularly numerous branches. Unlike other endings such as the bishop and knight checkmate, it is difficult to create transpositions and simplify the tree, because giving the defender a single move of extra time generally creates a host of new defensive possibilities, each requiring a unique sequence of moves to defeat. I tried keeping track of the directions the pieces move, but there are very few repeated patterns. This ending deserves its reputation.

   In the end, I decided not to include a tree diagram this complicated (partly because it is difficult to fit neatly on the printed page), so you will have to be content with just the Philidor position.

7. *Bishop and Knight checkmate*: With optimal play, the starting position is mate in 17. This tree diagram sacrifices a couple of moves of speed in order to make the overall tree smaller. I am comforted that in his groundbreaking *Secrets* ending book series, John Nunn was also willing to sacrifice a few moves of speed in order to simplify a technique. John Nunn (1994) Secrets of Pawnless Endings. Batsford, page 48. Nunn spent moves in order to make the winning method easier for human understanding. In *The Chess Memory Palace*, we do not care about how intuitive the moves are, but we do care about overall tree size.

   The small size of the bishop and knight checkmate tree is achieved through extensive use of specified piece moves and ladders, which allow us to slowly constrict Black's king without keeping track of exactly where it is. If Black's king is preventing our favoured move, the ladders create a zugzwang so that we can advance next turn.

   If any reader is so inclined, there is lots of potential research to create the smallest possible tree diagram for any given endgame position. And, one step further, to create the smallest possible *single* tree diagram for a

range of endgame positions. See the final example for some inspiration of what is possible.