Problem Solving

- *"A problem exists if a living organism has a goal but does not know how this goal is to be reached" - Karl Duncker*
- ***Necessary if you want something that is not immediately available:***
    - E.g solving a puzzle, selection of a chess move, removing a broken light bulb, cooking a new dish, writing a story
    - Other animals/species have goals and solve problems too
        - e.g. New Caledonian crows can both use and fashion tools to reach meat inside a glass tube
            - Females retrieved food on 10/17 trials, though only one male did so
            - Spontaneous (not S-R learning) → however they might curve twigs in their natural environment which may have been applied

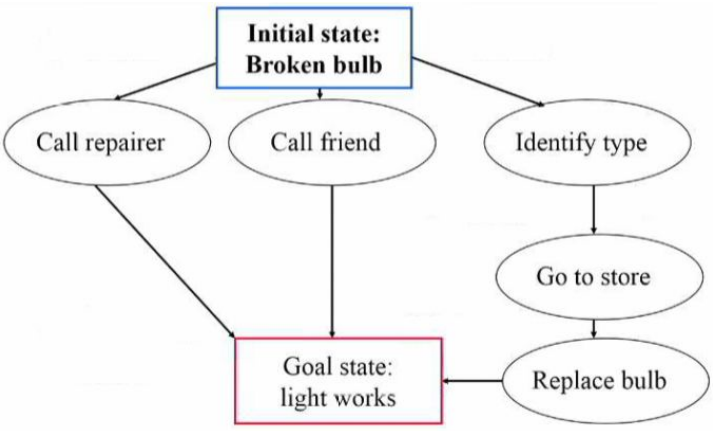
Approaches to Problem Solving →

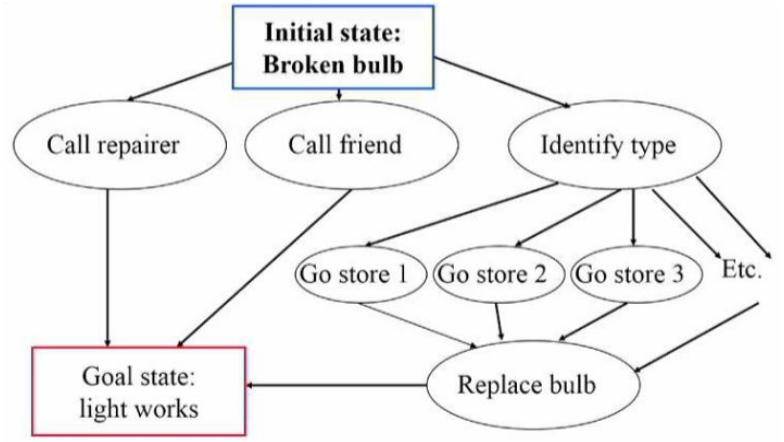
- **Gestalt Approach**
    - Emphasised the importance of *changes in perspective, prior knowledge, assumptions* during problem solving
    - Problem solving relies on *representation*
    - *Kohler (1925) →*
        - Studied chimps solving problems (e.g. banana hanging from wire above, chimps stacked boxes and climbed on top to reach)
        - Chimps are recognising these boxes can be used in other ways
            - Changing representation of the boxes → containers or building blocks
    - *Duncker (1945) →*
        - Tend to solve problems by looking for analogies between current situation and more familiar situations
    - Approach demonstrated a number of important phenomena
        - Especially *restructuring representations*
            - *"Productive Thinking"* (Wertheimer, 1945)
            - Barriers to problem solving are usually wrong representations
            - To solve a problem, must restructure representation appropriately → *productive thinking*
    - ***Functional Fixity →***
        - As we're *faced with situations/problems* in daily life, *we develop mental set*s → tend to see things in a certain way/use certain solutions
        - We may *fail to notice novel uses of objects* because of this (difficulty in restructuring representation of the function of an object)
        - *Duncker's Candle Problem (1945):*
            - Presented with a set of objects (candle, matches, box of tack pins) and you want to attach the candle to the wall

        - The function of the box appears to be a container for drawing pins, but it can also be used as a platform for the candle
        - Key to solving this problem was restructuring representation of the box → *overcoming functional fixity*
            - **86%** solved the problem when the box was empty but only **41%** solved when the pins were in the box *(Anderson, 1952)*
- ***Set Effects (or Einstellung)*** →
    - Tendency to do things in the same way/use certain solutions
    - *Luchins' (1942)* problems:
        - Three water jugs of given capacities (but the jugs are not full, so you don't know how much water they contain)
        - The goal is to obtain an exact amount of water
        - e.g. Goal is to get exactly *5 units* of water
            - *Jug A:* 18 unit capacity
            - *Jug B:* 43 unit capacity
            - *Jug C:* 10 unit capacity
            - *Solution* → Fill Jug B, then pour water into Jug A and twice into Jug C
        - Gave people new problems (different capacities and unit goals) which could be solved using the exact same procedure (or an easier procedure)
        - e.g. Goal is to get 25 units of water:
            - *Jug A:* 38 unit capacity
            - *Jug B:* 59 unit capacity
            - *Jug C:* 3 unit capacity
            - *Solution 1* → Fill Jug B, then pour water into Jug A and twice into Jug C
            - *Solution 2* → Fill Jug A, then pour water into Jug C (easier)
        - Found people tend to use the previously used (but more difficult) solution → evidence of set effects
        - After a sequence of similar solutions, most people fail to notice an easier alternative solution
    - *Discovery of Neptune (1846):*
        - Urbain Le Verrier applied Newton's laws to anomalies (inconsistencies) in Uranus's orbit to predict the location of a planet (its gravitational pull would account for these inconsistencies)
        - Off this success, applied the same solution to discovering other new planets
        - Noticed a "wobble" in Mercury's orbit (1859), and from this predicted the planet "Vulcan" → no planet found

            - ❖ Many people believed it existed (some claimed to have seen it) because it fit with current science → confirmation bias
            - ❖ Einstein's *Theory of Relativity* later came to explain Mercury's orbit
        - Reported that he kept issuing new alerts/predictions throughout his life until he died in 1877
            - ❖ Set effects can be long-lasting

- **Problem Solving as Search**
    - Response to Gestalt Approach → seemed largely *descriptive*
        - Identified a lot of interesting phenomena but no good explanations for these
        - *Unanswered question* → what is the ***process*** of problem solving?
    - *Useful Terminology:*
        - *State* → specification of the situation (e.g. ingredients on bench)
        - *Goal* → desired state of the situation (e.g. a lamb roast)
        - *Operator* → an action that changes one state into another (e.g. chopping vegetables, mixing sauces together)
        - *Solution* → a sequence of operators that transforms initial state into goal state (e.g. recipe)
        - *Constraints* → restrictions on what can be done (e.g.
    - ***Newell and Simon (1970):***
        - Conceptualised problem solving as a *search through a problem space* of possibilities
        - Search can be physical (e.g. maze, breaking into a safe) or mental
        - Starts with a situation we want to transform into something new
            - Do so by applying different options we have
        - Often *can't be an exhaustive search* (e.g. chess), so strategies are required (i.e. heuristics)
        - Approach came out of early work on *Artificial Intelligence*
            - Computers are not good at restructuring representations, but very good at searching (if this is how computers solve problems, maybe we do too?)
    - *e.g. Replacing a Lightbulb as Possibility Search:*





    - Even for simple problems, the search space can become large (and efficient ways of searching are required)
- *General Problem Solving Methods*
    - *Newell and Simon* tried to specify general problem solving methods
        - Methods are required outside of just exhaustively trying all possibilities
    - ***Method*** → a *procedure* for *performing a search for a solution*
        - If appropriate method is not clear, we use heuristic strategies
            - *Heuristics* can help obtain a solution (but it is not guaranteed)
            - Contrasted with an *algorithm* (guaranteed to produce a particular answer, e.g. mathematical formula)
    - **Generate-Test Method**
        - Randomly generate a solution, then test it
        - e.g. breaking combinations (trying random different combinations until the lock opens)
        - *Advantages:*
            - Requires no knowledge
        - *Disadvantages:*
            - Sometimes ineffectual
            - Generation of solutions may be hard
            - Testing solutions may be hard
            - Search space can be very large
            - Can be very slow to reach solution
    - **Difference Reduction Method (Hill Climbing)**
        - Try to reduce difference between current state and goal state
            - Take one step at a time in the appropriate direction
        - *Advantages:*
            - Steps can be small (don't need to know a solution, just what will get you closer)