Chapter 10: Neural basis of learning
Learning activity suggested answers

Learning Activity 10.1 (p. 376)

Explain whether each of the following human behaviours is best described as a learned behaviour (L), reflexive behaviour (R), fixed-action pattern (FAP), behaviour due to maturation (M), or more than one of these (for example, L and M).

- **emotional attachment by an infant to a caregiver:** widely regarded as learned behaviour (L). Consider deprivation studies (e.g. infants raised in orphanages) and Harlow’s research on early experiences of infant rhesus monkeys.

- **speaking in high-pitched ‘baby talk’ to an infant:** widely regarded as learned behaviour (L). Possibly fixed-action pattern (FAP). Some psychologists and researchers have proposed that this type of ‘baby talk’ (called ‘motherese’ or ‘parentese’) occurs universally across all cultures and is a species-specific adaptation, e.g. GA Bryant and HC Barrett (2007), ‘Recognizing intentions in infant-directed speech: Evidence for universals.’, in Psychological Science, 18(8), 746–51.

- **being scared of snakes:** widely regarded as learned behaviour (L). Typically acquired through classical conditioning, operant conditioning and observational/social learning processes. Some psychologists have proposed that we may have a biological predisposition to develop fears of certain objects, such as snakes, which represent a natural threat to our survival (e.g. see Box 13.6. p. 652). However, there is scant empirical evidence to support fixed-action pattern (FAP).

- **scratching an itch:** reflexive behaviour (R). Usually an automatic, involuntary response to activation of sensory neurons on the skin’s surface. Note that the scratch reflex has been widely described.

- **nodding in agreement:** widely regarded as learned behaviour (L). Although observed cross-culturally, cannot be considered to be a fixed-action pattern (FAP).

- **smoking cigarettes:** learned behaviour (L). Consider role of observational/social learning processes in acquisition and maintenance.

- **perceiving an illusion:** widely regarded as learned behaviour (L). Some visual illusions/mistakes in visual perception may involve physiological and/or cognitive processes, so maturation of the nervous system may play a role.

- **whistling:** maturation (M). Although influenced by learning, primarily depends on developmental processes underlying coordination of physical actions involved in whistling, e.g. young infants cannot whistle no matter how much they practice.

- **walking:** maturation (M). Depends on development of the body and nervous system structures underlying this type of mobility.

- **playing:** maturation (M) or learned behaviour (L). Which of the two is dependent on how play is defined and the type of play behaviour observed, e.g. newborn is not capable of social play like that of an older child because of neurological and physical limitations. Consider significant influences of experience on adolescent and adult play.
• curiosity: widely regarded as learned behaviour (L) or an aspect of learning. Sometimes described as an innate/inborn drive influencing motivation that is first observed soon after birth, but cannot be described as reflexive, dependent on maturation or a fixed-action pattern.
• sleeping: fixed-action pattern (FAP). All people sleep and a typical night’s sleep has common characteristics. May be influenced by maturation and learning, but cannot be described as either.
• loving: widely regarded as learned behaviour (L). Consider operational definitions and variations in the expression of loving behaviour among people within and across different cultures.
• roller-skating: maturation (M). Primarily depends on development of the body and nervous system structures underlying this type of coordinated physical activity (e.g. can a pre-mobile infant roller-skate?) Influenced by learning as it involves unnatural movements and specialised equipment, e.g. learning how to manipulate skates to stop, move forward/backward and turn without falling.

**Learning Activity 10.2 (p. 377)**

1

a Define the meaning of the term learning.
Learning is a relatively permanent change in behaviour that occurs as a result of experience.

b Briefly describe three key characteristics of behaviour that is learned.
Key characteristics may refer to:
• results from experience
• involves relatively permanent change in behaviour (but modifiable)
• change may occur immediately or gradually over time
• change may be latent or delayed
• can occur intentionally or unintentionally
• can be an active or passive process
• ongoing throughout the lifespan
• observed in performance/what the organism does (but learning may be latent/remain ‘hidden’).

2 Differentiate between a learned response, a reflex action, a fixed-action pattern and behaviour dependent on maturation. Give an example of each, but use examples not referred to in the text.
• Learned response: a behaviour change that occurs as a result of experience and is relatively permanent, e.g. phobic response to a fear stimulus, text messaging.
• Reflex action: automatic, involuntary behaviour that does not require prior experience and occurs in the same way each time, e.g. pupillary light reflex, salivation in response to conditioned and unconditioned stimuli or when food enters mouth, patella (knee jerk) reflex.
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- Fixed-action pattern: an innate/inherited response to an environmental stimulus that occurs in the same way and is observable within a particular species or subgroup of a species, e.g. fighting for social or sexual supremacy amongst primates, wolves turning in circles before lying down to sleep.

- Behaviour dependent on maturation: a behavioural response dependent on a developmental process or developmental processes involving the orderly sequence of changes that occur in the nervous system and other bodily structures controlled by genetic inheritance, e.g. stranger anxiety in infancy, development of depth perception (operationalised as height awareness or fear of heights).

3 Smiling, laughing and crying are all observed in deaf–blind children who cannot have learned these responses by seeing or hearing them in others. Normally, each of these behaviours is seen within several months after birth. Some psychologists view this as evidence of fixed-action patterns in humans and suggest that these behaviours are programmed by our genetic inheritance.

a Do you agree or disagree with this view? Why?

Discuss student responses to clarify conceptual understanding of FAP. Note that smiling, laughing and crying:

- are expressed in a variety of ways within the human species (but with universally recognised characteristics)
- can be triggered by different stimuli for individual members of the human species
- may initially be reflex responses in deaf–blind children and subsequently become conditioned responses following parental/caregiver detection.

b Can someone learn to control a reflex response? If so, give an example. Explain your answer.

Yes. e.g. biofeedback training for control/self-regulation of certain ANS responses

Learning Activity 10.4 (p. 380)

Review questions

1 Describe the most prominent changes that occur at the neuronal level when learning occurs.

Changes may include:

- modification of existing connections between neurons at synapses within the relevant neural pathway/s e.g. reorganisation to connect to a another/new pathway/s
- strengthening of existing connections between neurons at synapses within the relevant neural pathways
- formation of new synapses and synaptic connections
- postsynaptic neurons become more and more responsive to the presynaptic neurons as a consequence of repeated stimulation.

2 Outline the roles glutamate and dopamine have in learning.
• initiates activity in postsynaptic neurons that receive information in a forming or established neural pathway for the relevant learning (and memory of the experience)
• repeated release during learning contributes to synaptic formation
• strengthens connections at the synapse

- dopamine
  - contributes to the strengthening of synaptic connections
  - pleasurable experience associated with its secretion at the ‘dopamine reward centre’ influences reward-based learning i.e. positively reinforce and motivate performance of certain activities that trigger its release

3 Why is LTP believed to be a crucial biological process for learning to occur?

Explanation should refer to role of LTP in:

- strengthening synaptic connections within between adjacent neurons that form the relevant neural pathway
- making postsynaptic neurons in a forming or established neural pathway of the learning more responsive to stimulation by presynaptic neurons, thereby enhancing communication within the pathway, which makes synaptic connections even more effective and enduring

4 a Explain the meaning of ‘neural pathway of learning’.

Explanation should refer to:

- a network/group of interconnected neurons/nerve cell assemblies that is active during learning/forms and/or is modified when learning takes place (and which probably also stores the memory of the relevant experience)
- connects one part of the brain to another

b Learning has been described as a process of modifying existing neural pathways or building new neural pathways. Comment on the accuracy of this description.

Commentary should refer to:

- the generally accurate nature of the description, especially from a biological perspective and with reference neuronal/synaptic changes observed to occur resulting in the establishment and/or modification of neural pathways; and
- brain plasticity, particularly developmental and adaptive plasticity with reference to experience

5 View the following YouTube video: How We Learn—Synapses and Neural Pathways (3:15 min) at www.OneStopDigital.com.au. Comment on the accuracy of the information presented.

This YouTube is recommended for student viewing as it provides a relatively simple and accurate analogy of important neural processes believed to occur during human learning.

6 Suggest a reason to explain why neural mechanisms of learning and memory are so alike that it can be difficult to isolate and differentiate between them.

Explanation should refer to the intertwined and inter-dependent relationship of learning and memory e.g. memory results from learning and involves neural storage of learnt prior
experiences for retrieved when needed – without learning, there is no formation or modification of neural pathways and nothing to encode and store within neural pathways

**Learning Activity 10.5 (p. 384)**

Evaluate the series of experiments by Rosenzweig and others conducted in the 1960s. You are required to:

- suggest an aim for the experiments
- construct a research hypothesis that could have been tested by the procedures used in the experiment
- identify the operationalised variables
- identify the different conditions of a typical experiment
- identify the type of experimental design used
- identify an appropriate procedure for allocating the research animals to different conditions
- briefly state the results obtained
- briefly state a conclusion(s) based on the results obtained.

**Example:**

Rosenzweig et al (1960s)
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Aim: to investigate whether experience in different environments can structurally alter the brains of rats

Operational hypothesis: laboratory bred rat pups raised in an enriched environment with informal opportunities for learning will show distinctive structural changes in the brain at the cortical tissue and neuronal levels when compared with rats of the same sex and from same litter raised in an impoverished or solitary environment with no opportunities for informal learning.

IV: environmental condition (‘standard’, impoverished’ or ‘enriched’)
DV: anatomical changes in the brain at the cortical tissue and neuronal levels

Experimental design: matched-participants

Group 1: ‘standard’ environmental condition—3 rats kept in a standard laboratory cage, with no opportunity for complex stimulation and informal learning

Group 2: ‘impoverished’ environmental condition—single rat kept in a standard laboratory cage

Group 3: ‘enriched’ environmental condition—group of 10–12 rats kept in a large cage, with a wide variety of stimulus objects, changed daily and provided opportunities for complex stimulation and informal learning

Random assignment: laboratory bred rat pups from the same litter and of the same sex were randomly assigned to different experimental conditions shortly after weaning.
After 80 days, all rats were autopsied and their brains dissected for examination.

Results: Group 3 rats (enriched’ environmental condition) showed distinctive brain structural changes at cortical and neuronal levels when compared with Group 1 and 2 rats:

- cortical tissue: thicker and heavier
- neuronal level: larger cortical neurons, longer and bushier dendrites, bigger synapses and new synaptic formation, more ACTH neurotransmitter present

Conclusions:

- The hypothesis was supported as rats raised in an enriched environment with informal opportunities for learning showed distinctive structural changes in the brain when compared with rats raised in the other environments.
- These results show that the brain can be altered by learning and experience.
Learning Activity 10.6 (p. 393)

1. Explain the meaning of plasticity in relation to the brain.

   brain plasticity: the ability of the brain’s neural structure or function to be changed by experience throughout the lifespan

2. Explain why the brain is considered to have plasticity with reference to two key points.

   Explanation of the brain’s plasticity should refer to:
   - structural change in response to experience, e.g. synaptic formation induced by learning, modification or creation of neural pathways induced by learning (or relearning)
   - functional change in response to experience, e.g. reassignment of function following damage.

3. Explain the meaning of developmental plasticity with reference to learning.

   Explanation should refer to changes in the brain’s neural structure in response to experience involving learning during the brain’s growth and development.

4. In what way do synaptogenesis and synaptic pruning demonstrate the plasticity of the brain?

   Both are dynamic processes resulting in physical change, specifically:
   - synaptogenesis results in physical change in the brain in response to experience through formation of new synapses,
   - synaptic pruning results in physical change in the brain in response to experience through elimination of synaptic connections following a period of disuse.

5. a. What is adaptive plasticity?

   adaptive plasticity: changes in the brain’s neural structure to enable adjustment to experience, to compensate for lost function and/or to maximise remaining functions in the event of brain damage

   b. In what way is adaptive plasticity similar to and different from developmental plasticity?

   Similarities include:
   - both involve change in neural structure due to experience
   - both involve synaptogenesis, e.g. sprouting for adaptive plasticity enables new synaptic connections
   - both can occur at any time throughout the lifespan.

   Differences include:
   - developmental plasticity is genetically predetermined, whereas adaptive plasticity may be environmentally determined, e.g. due to acquired brain injury
   - adaptive plasticity results in change in function, e.g. relocation/reassignment
   - not necessarily a sensitive period for adaptive plasticity

   c. Describe three neural processes that indicate and enable adaptive plasticity.

   Neural processes may include:
• rerouting: an undamaged neuron that has lost a connection with an active neuron may seek a new active neuron and connect with it instead
• sprouting: the growth of new bushier nerve fibres with more branches to make new connections
• reassignment of function to compensate for damage
• greater cortical representation in response to a certain experience, e.g. professional musicians, London cab drivers.

6 Give an example of research findings that support the occurrence of adaptive plasticity in response to:
   a everyday experience: should refer to research findings on change through extensive use in everyday life, e.g. concert pianists with larger than usual somatosensory cortical areas for finger control, professional quilters with highly developed areas for the thumb and forefinger, London cab drivers with larger hippocampal areas;
   b recovery from brain damage: should refer to research findings on reassignment of somatosensory cortical areas of monkeys following intentional parietal lobe damage, patient recovery from limb paralysis following brain damage due to stroke.

7 Explain how adaptive plasticity enables compensation for lost brain function and/or maximises remaining functions in the event of brain damage.
   Explanation should refer to:
   • reorganisation of structure at the neuronal level (e.g. rerouting and sprouting) or tissue level (e.g. cortical)
   • reassignment of function from damaged to undamaged areas (usually from and to adjacent or nearby areas and involving reorganisation processes such rerouting).

8 a In what way is the ‘timing of experiences’ relevant to brain plasticity for learning?
   Generally, certain ‘time periods’ in development are particularly well-suited to certain learning e.g. sensitive periods in development when there is greater neurological responsiveness to specific experiences and are therefore optimal times for that learning to occur.
   b Distinguish between sensitive periods and critical periods for learning with reference to two key points and a relevant example of each concept.
   Distinctions include:
   • sensitive periods tend to start and end gradually (if in fact they end), whereas critical periods usually have identifiable start and end times and tend to begin and end suddenly
   • sensitive periods are optimal times for exposure to specific experiences and optimal times for learning due to those experiences, whereas critical periods involve vulnerability to deprivation/absence of specific experiences
   • learning associated with a sensitive period can still occur outside that period, whereas learning does not occur during a critical period, may not occur at all e.g. imprinting
c) Distinguish between experience-expectant learning and experience-dependent learning with reference to an example.

- **experience-expectant learning:** occurs when the brain encounters the experience that is expected and the learning may not occur as well or at all if not encountered when expected. E.g., oral language acquisition, visual stimulation, hearing, coordination of vision and movement.

- **experience-dependent learning:** learning that occurs through exposure to a specific ‘experience’ at any time during an individual’s development. E.g., all our learning is experience-dependent but certain types of learning have optimal times, especially learning that is experience-expectant.