Can I Talk to a Squid? The Origin of Visual Communication Through the Behavioral Ecology of Cephalopod

Ryuta Nakajima(✉)

University of Minnesota Duluth, Duluth, USA
lazymonk22@gmail.com

Abstract. The quest of modernity has come to its final phase in the form of post modernism. Many past attempts to define "individualism" and "self" encountered the wall of linguistics structure and categorization, the governing principals of human consciousness. Postmodernism tends to recycle the façade of preexisting methods and theories, thereby creating fragmentation and dislocation. Simultaneously, computer technology is rapidly reshaping our visual culture by offering more streamlined production and distribution possibilities. Considering this environment, it is essential to investigate its effect and implication on the visual culture, by asking existential questions such as: Why do we make images? Where do they come from and what is their primary function? In order to pursue these rather difficult questions, my work focuses on the adaptive coloration of cephalopods' (squid, octopus and cuttlefish) as comparative models that can code and re-map visual information such as paintings, photographs, and videos. The genetically and evolutionally pure empirical data of the squid and cuttlefish not only uncover certain key information needed to understand the origin of visual communication, but also function as a catalyst that can redirect our culture away from the over-stimulated hyper reality. This, in turn, can create a valuable interdisciplinary platform to discuss the current trends in both art and science.

Keywords: Cephalopod · Contemporary art · Communication Zombies · Cuttlefish and body pattern

1 Introduction

Body patterns play an important role in predator/prey interactions, such as crypsis (Endler 1978) and disruption (Cott 1940) for many animals. They are also used for inter- and intraspecific communication such as agonistic or mating display. While most animals have unchangeable to slightly changeable body patterns (Cott 1940), coleoid cephalopods such as the octopus, squid and cuttlefish can rapidly change their body colors and textures, exhibiting unrivaled speed, complexity and variety of appearances. These appearances, for camouflage and communication, consist of a combination of chromatic, textural, postural and locomotor components (Hanlon and Messenger 1988; 1996; Moynihan 1985; Packard 1972; Packard and Hochberg 1977). Chromatic components are produced by neurally controlled ink-filled organs called

S. Yamamoto and H. Mori (Eds.): HIMI 2018, LNCS 10904, pp. 594–606, 2018.
https://doi.org/10.1007/978-3-319-92043-6_48

chromatophore (Messenger 2001), which are connected to a set of radial muscles that expand and contract the pigmented sac, changing its affective surface area (Hanlon 1982). Neurally controlled light reflective cells, iridophores, produce blue, green and pink colors while leucophores produce white color (Messenger 2001; Wardill et al. 2012). In the case of octopuses and cuttlefishes, chromatic components are also enhanced by altering physical skin texture from smooth to three dimensional by controlling dermal muscles called Papillae (Holmes 1940; Packard and Hochberg 1977). Postural components are defined by positional orientation of flexible muscular arms, tentacles, mantle, head and fins (Packard and Sanders 1971). Locomotor components are expression and movement of the entire body of the individual (Roper and Hochberg 1988). Each of these components can appear for seconds (acute) or for hours (chronic) and can be displayed in wide varieties of combinations to create the total appearance of the animal (Packard and Hochberg 1977; Hanlon and Messenger 1996).

My discovery of the remarkable ability of the cephalopods to change body pattern helped me realize uncanny similarities between the process of layer painting, which fuses multiple independent layers of information into a singular and comprehensive pictorial plane and the structural and cognitive process of cephalopods' camouflage, which is also composed of multiple layers of chromatophores creating a singular whole by filtering information provided by its environment. In short, cephalopods' camouflage parallels the process of painting and other image-making practices. Although the objectives for creating images are very different from each other—survival and reproduction for cephalopods and aesthetics and metaphysics for artists—the fundamental triple-step structure (exterior information, individual interpretation and visual output) remains similar between them.

In the past 9 years, I have conducted many types of body pattern experiments with pharaoh cuttlefish (Sepia pharaonis) as a study subject at the National Resource Center for Cephalopods in Galveston, Texas and at the University of the Ryukyus in Okinawa. In these experiments, I replaced the sediment found in the natural habitat of the pharaoh cuttlefish, such as rocks, sand and seaweed, with 20th century paintings, photographic documentations of 20th century events, and short videos, in order to solicit its camouflage behavior. The cuttlefish responded to visual information from each image by interpreting visual attributes of the image into artificially triggered camouflage patterns, which were photographed and video recorded for further analysis. Furthermore, the data gathered from the analysis was used as the fundamental visual structure informing my creative works.

Through this project, I seek to revisit our cultural past through the eyes of a cuttlefish. Our raison d'être and vision of the future rely heavily on reevaluation of the past, which relies, in turn, on the idea of the linear progress of time. However, as Aby Warburg, art historian and founder of Warburg Institute, suggested at the turn of the 20th century, the cultural past of humanity may have followed a much more complex, nonlinear path that intertwines diverse cultural differences with time. The behavioral ecology of cephalopods as an interpretive cultural model not only brings together two different academic fields as a hybrid model, but also may present new and exciting insights into our cultural past. In these ways, this project attempts to present an alternative linguistic structure of the visual language that opens up future possibilities in art and humanity.

1.1 Model of Representation

Umwelt, self-world (Von Uexküll and Mackinnon 1926), is a cognitive reconstruction of the information or signs gathered from our sensory organs. Each biological sensor (visual, audio, tactile, temperature, olfactory, etc.) is specifically tuned to select important exterior and environmental information which is vital to our own survival. This information is, then, sent to the brain for processing and codifying for simple rapid output response to the exterior world (Okutani 2013). Artistic creation, like painting, according to Paul Klee, is a mere reflection of the environment that surrounds the artist (Klee 1924). Hence, it is the representation of the *Umwelt* of the artist and the artist's function is in the translation rather than the creation. Similarly, cephalopods have their own *Umwelt* that is described by their sensory system, their brain and their output to the world in visually traceable body pattern responses. In these ways, both artists and cephalopods are producing visual representation of their *Umwelt*. If this hypothesis is true, then, using a comparative study of these two different visual response bio-systems, it is probable to detect the fundamental visual schematic of the total reality, which may otherwise be unattainable due to the limitation of both sensory systems and cognitions (Fig. 1).

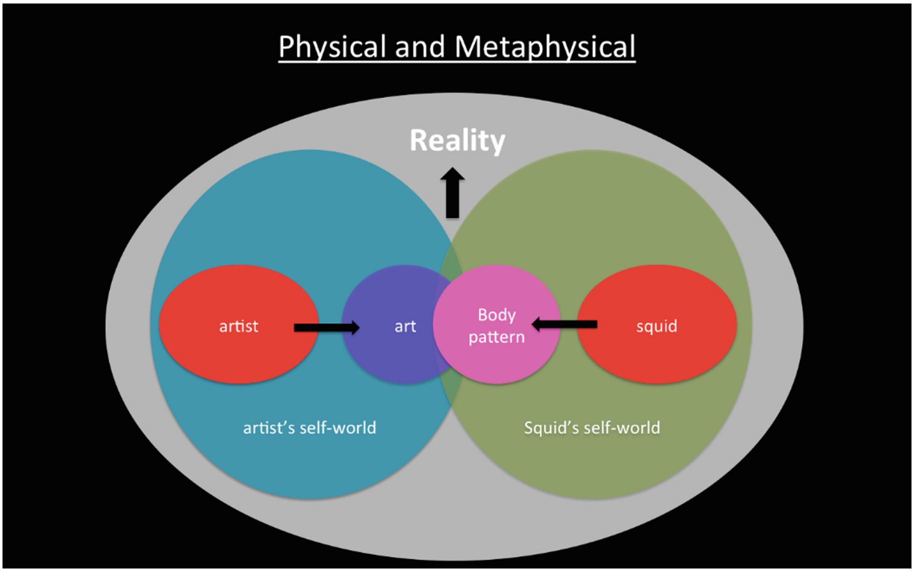
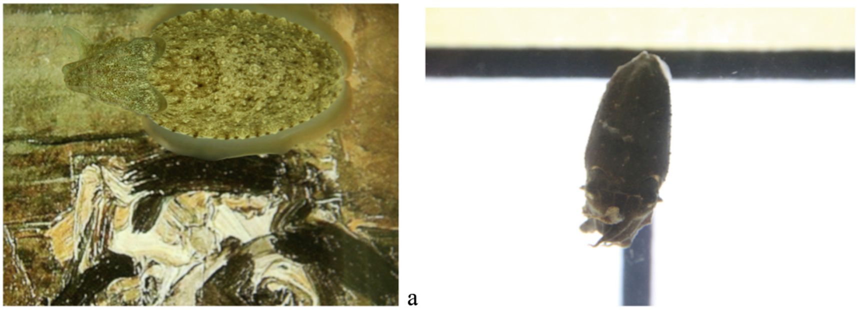


Fig. 1. The diagram is showing the relationship between the self-world of artist and squid and how the overlapping area may direct towards the larger reality. (Color figure online)

1.2 Can a Cuttlefish Match Paintings?

Upon conducting the experiment of replacing a cuttlefish's natural substrate (sand, rocks, corals, etc.) with varieties of 20th century paintings from the geometric abstraction of Piet Mondrian to the Japanese anime-influenced "super flat" paintings of

Takashi Murakami, it is clear that the cuttlefish is able to match its' body appearance to the given images. This experiment, which was conducted from 2009 through 2011, tested over 100 individual animals with 80 stylistically unique paintings and yielded hours of video data. A careful review of still images taken from the videos showed certain specific trends. Due to their physiological limitation of chromatophores and iridophores, the cuttlefish could not produce a highly saturated color combination (Fig. 2).



a b

Fig. 2. These images show *Sepia pharaonis* matching its body pattern to Frank Auerbach (a) and Piet Mondrian (b)'s painting. (Photographed by Ryuta Nakajima.)

In addition, their responses to dangerous predators depicted in some of the paintings did not include defensive postures that the cuttlefish would exhibit in nature. On the other hand, cuttlefish performed very well to both gestural and geometric abstraction in paintings, matching their patterns more accurately to the paintings. Such paintings are constructed mainly with formal measures, qualities and weights, such as line, tone, colors, shapes, hues, and salutations, without, in most cases, any figure or object representation (Klee 1924). Ironically, this lack of specific objects and figures produces images that resemble natural landscapes or cityscapes and contain organic elements. It is precisely within these natural elements, organized according to a certain aesthetic and geometric principle, that the cuttlefish exhibited an ease in matching its body patterns, which are a simplified and geometrically organized representation of Nature. It is also important to note that there seems to be a certain visual threshold where the cuttlefish differentiates between animate and inanimate. For instance, the painting of Frank Auerbach is a gestural, figurative abstraction in which most viewers see a figure; the reaction of a group of cuttlefish indicated more of a landscape with no sense of a figure.

1.3 Cephalopod Art

The data collected are used to produce various types of artwork for exhibition. In the early stage, paintings and drawings were used to track the body pattern change of the cuttlefish in relationship with the substrate images. After gaining access to laboratory animals, the visualization methods changed to predominantly photograph, video and sculpture installation. One of the most comprehensive solo exhibitions was produced in collaboration with the Minneapolis Institute of Art [MIA] and the University of the Ryukyu Cephalopod Research Laboratory. In this exhibition, there were six large-scale photographs (Fig. 3) of the cuttlefish disguises formed in response to selected art works from the MIA collection, 51 cuttlefish sculptures with images taken from the videos painted on them as their body patterns. This exhibition created a sense of synergy between art and science, nature and culture, animate and inanimate. In this way, it displayed the interconnection between nature and culture by using a cephalopod as a metaphorical vehicle inviting curiosity and discovery.

Fig. 3. Large-scale photograph produce for an exhibition at Minneapolis Institute of Art.

1.4 Creating a Catalog of Body Patterns of the Pharaoh Cuttlefish

Over 100 species of cuttlefish have been described (Jereb et al. 2005). The pharaoh cuttlefish, *Sepia pharaonis* (Ehrenberg 1831 1999), is distributed in tropical coastal waters in the Indo-Pacific region (Norman and Reid 2000; Nabhitabhata and Nilaphat 1999). Although there were previous studies done of the species, many focused on the camouflage and its visual cues with no extensive catalogue of body patterns that could be used for more accurate analysis of the responses that further experiments required. In light of this, I constructed a catalogue of the chromatic, postural and locomotor behaviors for use as a tool in behavioral monitoring, quantitative analysis, and species identification. I consolidated the data from 2010, 2011, 2012 and 2014 for a total of 325 HD videos and 9,799 still images obtained and analyzed. Through this process, 53 chromatic, 3 textual, 11 postural and 9 locomotor components were identified and described (Nakajima and Ikeda 2017). This study was conducted in an artificial environment and the complete repertoire of *S. pharaonis* body pattern may be larger than what the study describes. However, compared with studies of other related cuttlefish species and their ethogram, the number of components represented are compatible and reasonable (Fig. 4).

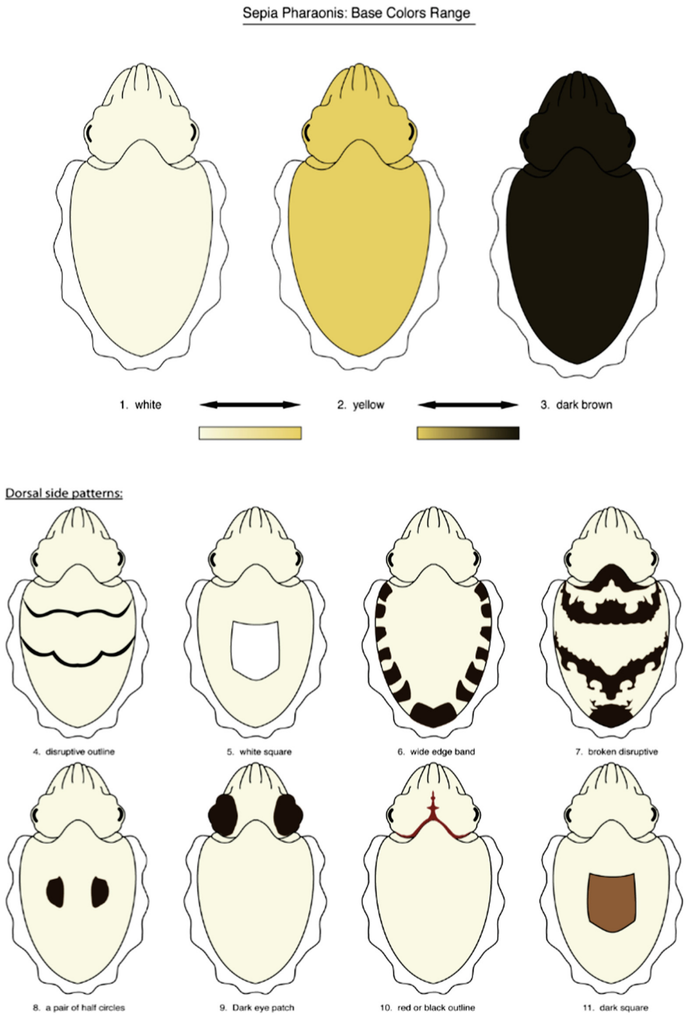


Fig. 4. An example of illustration describing chromatic components of *S. pharaonis* (Nakajima and Ikeda 2017)

2 Communication

The catalogue clearly represents the remarkable variety of body pattern expression that *S. pharaonis* can produce. However, isolating body pattern, that used for camouflage can be categorized into three major forms: uniform, mottled and disruptive (Hanlon and

Messenger 1988; 1996) with variations within each category (Zylinski et al. 2009), which may not require the entire collection of chromatic components and possible body patterns. The natural progression of question would be to ask What are all these components for and what are the cues that trigger the appearance of them? and ultimately asking such questions as Are they using body pattern for communication and is there an overlap with our communication system? While these questions are certainly important, they are also extremely problematic and abstract.

2.1 Agonistic Behavior

Agonistic behavior is a display of aggression which includes threats, retreats, placation and conciliation (Scoot and Fredericson 1951). Of the 9,799 images which were used to create the catalog, one image was particularly unique. In this image (Fig. 5.) the chromatic components of the cuttlefish and the visual components of the Ngady mask showed incredible similarity. Both contain the dark eye ring, blue mantle-like pink lines on each arm and a mottled pattern on the mantle. This similarity between the cuttlefish and the mask is clearly not manifested from the necessity to camouflage; rather both are functioning as an embodiment of aggression. The chromatic components and the overall body pattern expression are intended to induce certain fear and a startling reaction to the object upon which the pattern is projected. In short, the pattern functions as a trans-species communication symbol that is genetically programed and can be read without depending on rhetorical knowledge of visual language. Hence, this particular agonistic display may possibly possess the clue to understanding the shared visual schematics.

Fig. 5. *S. pharaonis* is displaying fully articulated agonistic body pattern with dark eye ring, blue mantle-like, pink lines on each arm, flat and expanded body shape etc., reacting to Ngady mask show below. There is an uncanny similarity between the chromatic components of the cuttlefish and the mask. (Color figure online)

2.2 Zombies' Chromatic Components Analysis

In order to further understand the relationship between agonistic display found in both cuttlefish body pattern and Ngady mask, zombies were used as a comparative model. Zombies are an imaginary construct that is designed to induce an interspecific emotional response of fear. Zombie folklore originated in Haiti in the 17th century when African slaves were brought to Haiti to work on the sugar cane plantations. Although there are many versions of cultural fascination with reanimated human corpses, for this study, 100 zombie samples are taken from the Post George Romero's film *Night of the Living Dead,* which later became an American pop culture icon. The sampled Zombies are from commercial films, Halloween costumes, makeup tutorials, etc., from an Internet image search. Every image was deconstructed and analyzed for chromatic components (Fig. 6).

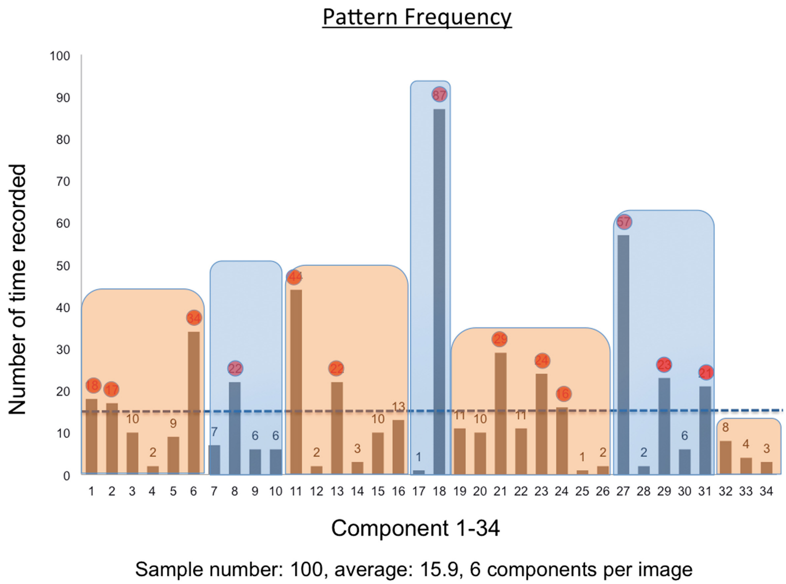


Fig. 6. Zombie chromatic components frequency chart

34 chromatic components (Fig. 7.) were detected which were divided into 7 facial zones, where each component is mutually exclusive within the zone. The average number of occurrences is 15.9 times with an average number of chromatic components per image of 6 components. The component with the highest number of occurrences was #18, dark eye patches, at 87 times. 12 components (1, 2, 6, 8, 13, 18, 21, 23, 24, 27, 29 and 31) were above the mean of which 6 components had significantly higher occurrences within the zone. Based on this simple observation and analysis, it appears that there are four dominant components (pale complexion, dark eyes, white pupils and bloody mouth) that are absolutely necessary to create a zombie and four more components (missing lips, dark lips, cuts, and decomposition) that are subdominant and

Fig. 7. Zombie chromatic components chart

enhance overall appearances. The four dominant components can be combined together to create a total appearance that might be considered the archetype of zombie, which is the visualization of human interspecific fear. Combining the archetype zombie with four subdominant components produces 12 different overall appearances that cover most of the visualization of zombies produced by the media industries (Fig. 8).

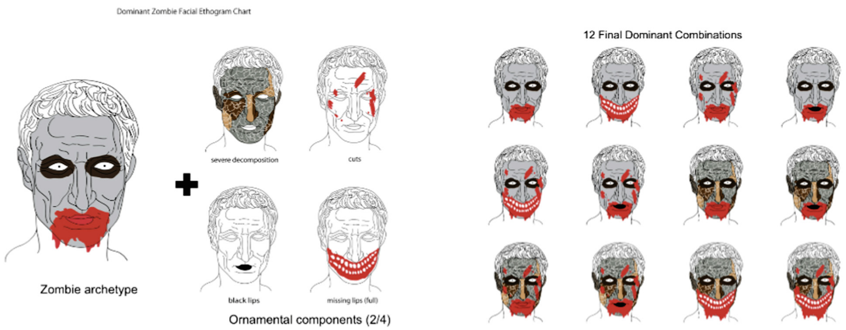


Fig. 8. 4 dominant Zombie chromatic components are combined to produce the zombie visual archetype. Four ornamental components are added to produce 12 possible total appearances.

Comparing the chromatic components of cuttlefish, mask and zombie archetype, there is a considerable similarity between them. Although this is a pseudo-scientific experiment and comparison between these three seemingly dissimilar visual elements, it seems to me that there is a definite collation between chromatic components that induce fear responses across species. These components function as signs or visual cues that communicate potential danger in engaging with the displayer. In this way, it reduces the chance of predation and physical engagement with the receiver of the information. Hence, the body pattern has to be trans-specifically effective as a basic level of inter- and intraspecific communication (Fig. 9).

Fig. 9. Chromatic components are very similar between cuttlefish, zombie and Ngady mask

2.3 Cuttlefish Cosplay

I further investigated the notion shared visual components to induce a sense of fear, I asked Myu Amatsuka, a professional Japanese cosplayer, to recreate 3 selected body patterns of cuttlefish. The objective of this experiment was not communicated to her during this experiment. 3 body patterns were produced and photographed. The result (Fig. 10.) also shows considerable similarity with zombie make-ups. Although, there are evidences of Amatsuka's interpretation has been influenced by *Ika musume* (squid girl), a famous Japanese anime character, three manifestations expressed the gradual transformation of Amatsuka into something resembling zombie like character rather than a cuttlefish. Furthermore, it is important to note that the Amatsuka's postural presentation has also changed as the make up changed expressing a potential shift in her psychological state. Here, the chromatic components have effected not only the viewers reception of them, but also effected the psychology of the subject applying the makeup. It is also interesting that the final outcome (image on the right) is very similar to the Ngady mask as well. From these comparative studies, the trans-specifically effectiveness of body pattern is reconfirmed.

Fig. 10. Cosplayer's interpretation of three distinctive body patterns of cuttlefish.

3 Conclusion

From art to science, my work tries to find a new and more direct communication method. I believe that artwork is not a product of self expression, rather it is a product of biological necessity that helps us connect with our environment. The human sensory system has been fine-tuned in the course of evolution to detect and isolate specific information which is important for spatial navigation, predator prey interaction, selecting mating partner and so on. In order to reduce the margin of error, the system is designed to omit and simplify millions of variables and details that constantly surround us. Similarly, cephalopods, in their self-world, are doing the same. By comparing the human and the cephalopod visual communication systems, I hope to isolate important visual cues that induce certain emotional reactions without depending on linguistic categorization or logical understanding. Further more, if one is able to create a visual communication model that is based on this minimal yet effective visual communication system, that increases the level of empathy and understanding with others that helps to cultivate a new consciousness.

References

Cott, H.B.: Adaptive Coloration in Animals. Methuen, London (1940)

Endler, J.A.: A predator's view of animal color patterns. In: Hecht, M.K., Steere, W.C., Wallace, B. (eds.) Evolutionary Biology. EBIO, vol. 11, pp. 319–364. Springer, Boston (1978). https://doi.org/10.1007/978-1-4615-6956-5_5

Nabhitabhata, J., Nilaphat, P.: Life cycle of cultured pharaoh cuttlefish Sepia pharaonis Ehrenberg, 1831. Phuket Mar. Biol. Center Spec. Publ. **19**, 25–40 (1999)

Hanlon, R.T.: The functional organization of chromatophores and iridescent cells in the body patterning of Loligo plei (Cephalopoda: Myopsida). Malacologia **23**, 89–119 (1982)

Hanlon, R.T., Messenger, J.B.: Adaptive coloration in young cuttlefish (Sepia officinalis L.): the morphology and development of body patterns and their relation to behaviour. Phil. Trans. R. Soc. Lond. B **320**(1200), 437–487 (1988)

Hanlon, R.T., Messenger, J.B.: Cephalopod Behaviour. Cambridge University Press, Cambridge (1996)

Holmes, W.: The colour changes and colour patterns of Sepia officinalis L. J. Zool. **110**(1-2), 17–35 (1940)

Jereb, P., Roper, C.F.E., Vecchione, M.: FAO species catalogue for fishery purposes. In: Cephalopods of the World. Food and Agriculture Organization of the United Nations, Rome, pp. 1–19 (2005)

Klee, P.: On modern art. In: Herbert, R.L. (ed.) (1924)

Messenger, J.B.: Cephalopod chromatophores: neurobiology and natural history. Biol. Rev. **76**(4), 473–528 (2001)

Moynihan, M.: Communication and Noncommunication by Cephalopods. Indiana University Press, Bloomington (1985)

Nakajima, R., Ikeda, Y.: A catalog of the chromatic, postural, and locomotor behaviors of the pharaoh cuttlefish (Sepia pharaonis) from Okinawa Island, Japan. Mar. Biodiv. **47**(3), 735–753 (2017)

Norman, M., Reid, A.: A Guide to Squid, Cuttlefish, and Octopuses of Australasia. CSIRO Publishing, Collingwood (2000)

Okutani, T.: 『日本のタコ学』. Tokai University Press, Hadano-shi (2013)

Packard, A., Sanders, G.D.: Body patterns of Octopus vulgaris and maturation of the response to disturbance. Anim. Behav. **19**(4), 780–790 (1971)

Packard, A., Hochberg, F.G.: Skin patterning in octopus and other genera. In: Symposium of the Zoological Society, London, vol. 38, pp. 191–231 (1977)

Packard, A.: Cephalopod and fish: the limit of convergence. Biol. Rev. **47**, 241–307 (1972)

Roper, C.F.E., Hochberg, F.G.: Behavior and systematics of cephalopods from Lizard Island, Australia, based on color and body patterns. Malacologia **29**(1), 153–193 (1988)
Scott, J.P., Fredericson, E.: The causes of fighting in mice and rats. Physiol. Zool. **24**(4), 273–309 (1951)
Von Uexküll, J., Mackinnon, D.L.: Theoretical biology (1926)
Wardill, T.J., Gonzalez-Bellido, P.T., Crook, R.J., Hanlon, R.T.: Neural control of tuneable skin iridescence in squid. Proc. Roy. Soc. Lond. B: Biol. Sci. **279**(1745), 4243–4252 (2012)
Zylinski, S., Osorio, D., Shohet, A.J.: Cuttlefish camouflage: context-dependent body pattern use during motion. Proc. Roy. Soc. Lond. B: Biol. Sci. **276**, 3963–3969 (2009)