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Cognition as Choreography: The Relationship between Eye Movements and the Morphology of a Jōmon Flame-Style Pot

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Abstract: We report the results of an experimental study into the relationship between contemporary eye movements and the morphology of a jōmon flame-style pot. Using Material Engagement Theory (Malafouris 2013) and results from a previous phenomenological study (March 2020, 2022) we made three predictions concerning the pattern of body movement and eye gaze. Eight artists and 16 non-artists were invited to examine a jōmon flame pot in a museum while wearing Tobii 2 glasses to follow their movements. When the gaze and movement data were analysed, while both groups differed significantly on aesthetic measures taken before they saw the pot, this difference disappeared when their aesthetic reaction and the eye-tracking data were assessed. This preliminary investigation of mobile eye-tracking with a prehistoric artefact provides evidence that the morphology of the vase choreographed viewing patterns in a consistent way across these two groups.

1.1. A Brief Prehistory of Jōmon Flame Pots

The word "jōmon", "cord pattern" in Japanese, refers to the hallmark repetitive cord imprint on the sides of baked, clay vessels found across Japan and has subsequently come to refer metonymically to the culture that produced them. These ceramic artefacts and their stylistic evolution date the beginning of the jōmon period to at least 14,000 years ago and indicate the cultural continuity of a complex forager society that approached its end fewer than 3,000 years ago when the Yayoi culture arrived from the mainland, introducing rice farming and a much more restrained ceramic tradition (see Habu 2004; Kendrick 1995; Kidder and Esaka1968; Kobayashi 2004; Steinhaus and Kaner 2016; for more detailed accounts of jōmon culture). The morphological development of pottery defines six main stages to jōmon cultural evolution: (i) Incipient, (ii) Initial, (iii) Early, (iv) Middle, (v) Late, and (vi) Final stage.

Fire flame pottery (*Kaen doki*) (see Figure 1.1) appears towards the end of the middle stage (about 3500–5000 years ago). Finds were initially concentrated in the Echigo region of Japan (Nigatta Prefecture) but as further discoveries spread along the Shinano valley and beyond, becoming more stylistically heterogeneous, the appellation broadened to *kaen-gata doki*[1] (Ghobadi 2015). Nevertheless, shielded from the influences of pottery styles from surrounding regions, the relative isolation of the Echigo region enabled a unique and enigmatic style (*shinbo ninzaki*) to develop a style that Kobayashi (2004) separates into three chronological periods, with flame-type pots as the final, exuberant apogee. Flame-style pots themselves are further sub-divided into four groups by construction method and visual appearance. Ghobadi (2015) and Pearson (2007) provide additional contextual evidence to suggest that different styles may also have followed different patterns of usage and disposal. Those pots exhibiting the iconic flame, rim projections (Figure 1.1) are contained within group A. In this paper, we concentrate on an example of a group B pot (Figure 1.2) whose rim projections are generally less flamboyant (our choice of pot was determined by the need for participants in the study to have 360º viewing access in its habitual position). Neither group A nor B pots exhibit cord imprint. Instead, the base panels are decorated with vertically oriented bamboo tool incisions containing embedded, incised spiral motifs. All Flame-style pots were constructed using the coiling method: sides of a pot are built up by spiralling a cylindrical coil of clay onto itself in a circular motion.

The pots are not art as we conventionally understand it:[2] Lipid analysis suggests they were used to cook aquatic

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[1] Translation: fire-flame type pottery.
[2] Describing archaeological artefacts as "art" is controversial, see Robb (2017). Without re-visiting the debate here, two specific issues are

Figure 1.1. Flame pot (group A), 5000 BP. Earthenware, excavated from the Iwanohara Site, Nagaoka City, Niigata Prefecture, Japan. From the British Museum (on loan from the Nagaoka City Board of Education). Copyright by Paul L. March.

Figure 1.2. Flame-style deep bowl (group B), Middle jōmon period (2500-1500 BC). Earthenware, Japan. From the Robert and Lisa Sainsbury Collection. Copyright by Paul L. March.

animals (Lucquin et al. 2016, 2018) and their burial context suggests their use in the preparation of feasts (Pearson 2007). While the word "flame" refers to the extrusions that extend from the rim, and although scorch-marked sides clearly indicate their use in hearths, we have no way of knowing whether flame pot morphology was intended to evoke fire. Although some have taken a symbolic approach to jōmon pot motifs (Oh 2006; Naumann 2000), as the above summary suggests, flame pot scholarship has tended to avoid interpretative approaches in favour of a detailed typological methodology, beginning in the 1930s with the work of Yamanochi who set out to create a typological, relational network of jōmon pottery in order to reveal the detailed, shared and evolving mental template of the jōmon pot-producing community. Kobayashi has significantly developed this approach over his career. For example, he uses the typology of incipient jōmon pots to draw attention to the skeuomorphic relationship between their form and those of wooden containers and woven baskets (Kobayashi 2004). He also points out that the motifs on such pots lend themselves more easily to reproduction in wood or basket work than in clay.

> "While these objects may not have helped much with the technological developments needed for pottery making, they provided convenient models for shape ... The potters had images of these objects in their heads as they started to make pots, and for this reason the incipient Jōmon can be described as the 'image stage' in the history of the development of Jōmon pottery". (Kobayashi 2004, 34–5)

He goes onto suggest that early-stage pottery developed from the incipient stage by taking on forms and motifs that were more consistent with the plastic possibilities of clay. So, although Kobayashi argues that jōmon pots developed into vehicles for sharing "meaningful concepts [which] existed prior to the designs" (p. 45), implicit in his description is an acknowledgement first, that pre-existing objects served as "external representations" (Kirsh 2017) and second, that the material qualities of clay played a fundamental role in jōmon pot evolution. These observations will be relevant when we come onto Material Engagement Theory.

For Kobayashi, the ability of jōmon vessels to convey meaningful concepts became prominent during the middle jōmon period; arguing that the evolution of early to middle jōmon stage was characterised by a change in function from vessel as container to vessel as vehicle for the representation of shared community concepts.

> "The establishment of these narrative patterns indicates that Jōmon potters had moved from just holding

relevant. First, Robb points out that much of ancient "art" was made to be used and not just viewed. Second, he proposes that things that we call "art" in the west maybe usefully be considered as a subclass of a more inclusive category of "powerful objects". Likewise, Wells (2017) replaces "art" with the more generic term "visually complex objects" which he derives from the work of Gibson (1979) on direct perception and Gell's (1998) notion of the enchanting agency of certain artefacts.

> mental images of the object they wanted to create in their heads, to having particular concepts in mind, which they wanted to express through combinations of symbols, which carried meanings that would have been understood by other people in their community. In other words, by this stage, meaningful concepts existed prior to the designs used to express them, and these concepts were given a reality in the Jōmon world through appearing on Jōmon pots." (Kobayashi 2004, 45).

Kobayashi's analysis and the symbolic approach of Oh and Naumann assume that jōmon pot morphology contains a narrative that, if only it could be decoded, would shed light on the mind of the maker and her community.[3] This conceptual model is predicated on an ontological position called "hylomorphism" (Ingold 2010) dating back to Aristotle. According to this position, the form something takes can be abstracted from the matter from which it is made. Hylomorphism has important implications for how we understand the process of conceptualization. It provides the framework for a view of cognition as the exclusive and unilateral product of cortical activity that occurs through the manipulation of internal representations; jōmon people had thoughts in their heads which they subsequently expressed by modelling motifs on their pots and these motifs therefore replicate and represent those thoughts. This view is widely accepted within cognitive science (e.g., Boden 2004; and see David et al. 2004 for an introduction) but as Kobayashi's description of the early evolutionary stages of jōmon pottery suggests, the process of cognition may be better understood by considering the real-world to be an integral part of the process of conceptualization. In the next section we introduce a model that collapses the separation between mind and material change.

1.2. Material Engagement Theory

Material Engagement Theory (MET) proposes an ecological model of the mind that encourages a shift away from the search for meaning in the inscrutable shape of its motifs and towards the sensorimotor relationship facilitated by the physical presence of a pot. MET was advanced by Renfrew (2004) and Malafouris (2004), not within the conceptual or laboratory space of psychology but in relation to the material culture of archaeology. MET has since been considerably developed by Malafouris, (e.g., 2013, 2014, 2015, 2018). Below we briefly summarise the three main principles as they relate to reconfiguring a new perspective of a flame pot: The extended mind, material agency, and enactive signification. We take each in turn.

The Extended Mind. as initially put forward by Clark and Chalmers (1998) proposed that cognition routinely took place by manipulating entities in the environment and that, by co-opting these objects, the mind extended into the world. There is a crucial distinction to be made between this version and that proposed by MET. Clark and Chalmers maintained that the brain remained the cognitive hub, extending outward when it was propitious to do so. In Malafouris's version, the mind is not so much a place but a process; suggesting that cognition does not reach out into the world but is brought into existence through the interaction between humans and elements in the environment. This sets the stage for a performative analysis of pot-person interaction during which we concentrate, not on the tantalizing but chimeric hints that a pot might give about the mental structure of its makers, but on how pot and contemporary humans interact.

Material Agency. The above reformulation of the extended mind holds important implications for agency. In the Clark and Chalmers version, the decision to extend cognition beyond the boundaries of the brain remains a decision for the brain. The ontological basis of the MET version has much more in common with Heidegger's (1927) notion of *Dasein* in which the locus of mental activity is in the world, in relation to the world and part of the world. The individual human agent disappears to be replaced by the notion of agency as an emergent property of a transient system of activity, embedded and informed by the cultural-historical context and the material at hand. A flame pot is a vestige of that activity – a record of a cognitive process in which the plastic materiality of clay played an agential role during the pot's creation before going onto constrain and facilitate its own lifecycle. Malafouris (2013) refers to the mechanism by which this takes place as 'enactive signification'.

Enactive Signification. As we have seen, the surface structure of flame pots is normally broken down into individual motifs and treated as symbols that are thought to stand in or represent concepts that exist independently of a specific material manifestation. The arrangement of motifs is viewed in narrative terms, with each concept being assigned a linguistic meaning. In contrast, the systemic formulation of mind and agency we have outlined enables a radically different way of understanding how something comes to make sense. If the act of cognition takes place by and through the manipulation of material then, by coming into existence, the emerging structure is an act of signification. Meaning is expressed and experienced as behavioural-material intercalation rather than abstract-conceptual imagination.

Instead of portraying a pot as a reflection of the maker's internal mental representations and therefore as a key to unlocking them, enactive signification collapses the separation between signifier and signified, emphasizing the process of making itself; focusing attention on how a pot creates a non-linguistic meaning that is performed by and through the actions that occur in relation to its creation and use. The goal is not to reveal some deeper symbolism but to locate signification in the gestures encouraged by the presence of the pot. By their nature, enactive signs are therefore difficult, if not impossible, to translate into words and so they do not lend themselves easily to scholarship. What follows is therefore not an attempt to describe the meaning behind enaction but a prediction of how a pot's

[3] Evidence suggests that jōmon potters were women (Kobayashi 2004).

structure might organize behaviour: a prediction that can then be tested thanks to the technology of mobile eye-tracking.

1.3. Flame Pot Construction

As mentioned, a flame pot was constructed using the coiling method - rolling clay into cylindrical lengths and building up the vessel walls by spiralling these over each other. This coiling gesture determines a circular symmetry which is expressed in the ubiquitous conical base. As the walls rise, the visible, horizontal stratification left by the coils is progressively effaced and replaced by vertical embossed lines that encourage the gaze upwards, past proto-spiral forms that foreshadow the asymmetry produced by the sculpted spirals at the rim of the pot (see Figures 1 and 2). In this way, the presence of the spiral protrusions that undermine symmetry also simultaneously and paradoxically refer to the act of coiling - the method that created the symmetry in the first place. Seen thus, the construction process performs a semiotic transformation. In the first stage, the stratified lines left by the coils are indexically linked to the latter. These traces of construction are then effaced and replaced by vertical pathways that lead upwards towards an iconic sign of the production technique; iconic because the sculpted spirals are not caused by the coiling method but make reference to it. The vertically organized surface pattern of the base contrasts with the spiralling motifs extending from a horizontally organized upper rim. We therefore suggest that, in partnership with the viewer, the pot's morphology simultaneously develops and deconstructs the symmetry of the production method, encouraging a dynamic, experiential re-enactment of the process of making. By re-working the surface structure of the vase, the act of construction is transformed from being an event that is fixed in the past to one that is brought into the present, sensorial experience of the viewer. We therefore predict that the unique morphology of a flame pot will constrain the way a viewer looks at it, such that different viewers will show similar patterns of eye movement. Tinio (2013) also suggests that the process of viewing recapitulates the process of making but his argument is based on a model in which that artist moves from initial (internal) conception to construction to final adjustments. The viewer reverses the direction, recognizing first the final touches, second evoking semantic inferences, and third seeking to understand the artistic intention. In contrast to Tinio, the MET approach suggests that intention and action, signification and creation are collapsed.

Recent, neuro-scientific research, inspired by Gallese's "embodied simulation theory" (see Williams, Mcsorley, and Mccloy [2020] for a recent review) seeks to demonstrate the existence of a shared aesthetic sensibility between artist and viewer which is mediated by the visual artistic gestures (e.g., brush strokes or sculpted marks) in an artwork. It is important to note that we are not arguing here for a simple "bottom-up" processing of the pot which highlights visually salient points. Rather, we suggest that the relationship between the viewer and the pot is an act of enactive signification in which meaning is extracted not through abstracted, semantic inference but by engaging with material form.

1.4. Eye-tracking

Eye-tracking involves the tracking of corneal reflections to monitor gaze patterns and, by inference, attention and underlying cognitive processes (Eckstein et al. Bunge 2017). The premise is that attention and gaze are linked, with gaze paths serving as a "window on mind and brain" (Dowiasch et al. 2019, 1) However, the relationship between gaze path and attention is not clear-cut and should not be assumed (Orquin and Holmqvist 2018). Part of the danger of eye tracking is that it encourages an automatic mind-eye inference– i.e., a longer fixation indicates deeper cognitive processing – but this is not a valid interpretation of the data. "There is indeed a relationship between thinking and looking but this relationship must be proved rather than just assumed because of its many caveats and exceptions" (Orquin and Holmqvist 2018, 7). It is also unclear whether eye movements reflect externally or internally directed processing. While there is some evidence that internally focused and externally focused cognition have different eye patterns, the results from empirical studies are complex and contradictory. Indeed, Reichle et al. (2010) found that rather than being associated with deeper processing, longer fixations were associated with off topic mind-wandering. But in this study, we nimbly sidestep this controversy. We do not seek to use eye tracking to reveal the structure of an inner mind, our interest lies in the opposite direction; in whether there is a predictable relationship between eye movements and a thing-in-the-world. For this, we need only a route-map showing "where the eye touches the clay" (Malafouris 2019, personal communication). In sum, we are interested in whether there is a predictable relationship between movement and morphology.

Until recently technological limitations restricted eye-tracking research to the lab-based analysis of two-dimensional images. Published research using eye-tracking in experimental archaeology is therefore exclusively lab-based. Lab work allows large sample sizes of both participants and artefacts and facilitates automated quantitative analysis (see for example Criado-Boado et al. 2019). The research reported here has only been possible in the last few years, with the development of lightweight, portable eye-tracking equipment capable of being quickly and reliably calibrated for three-dimensional stimuli, with no calibration slippages (Niehorster et al. 2019). While the sampling rate of mobile equipment is lower than that of static trackers it is accurate enough for the study we are presenting (Dowiasch, Wolf, and Bremmer 2019).

The use of mobile technology allows us to explore the relationship between gaze and aesthetic appreciation not with an image of an artefact but with the artifact itself; a development that is vital to an understanding of enactive as opposed to semantic signification. It is

important to note that mobile eye tracking does not resolve all methodological problems. Although its use can lead to freer engagement with an artefact and allows us to move away from presenting artefacts on a screen, the engagement remains structured by the context, as we discuss later. In addition, engagement with an artwork is likely to be informed by training and expertise: Eye tracking fixation patterns predict differences between expert and novice (Antes and Kristjanson 1991; Vogt and Magnussen 2007). The central thesis is that an expert's pre-existing cognitive plan directs their eye movements and allows for more efficient processing of the salient features of the stimulus - although the mechanism is still under debate (Gegenfurtner, Lehtinen, and Säljö 2011; Pihko et al. 2011). It is therefore plausible that artists and non-artists react differently to the pot reflecting different levels of expertise, with artists' eye movements displaying a greater level of engagement with its construction. As we outlined above, this higher level of engagement may be mediated by a sensorimotor appreciation of indexical signs (see also Massaro et al. 2012).

1.5. The Current Study

Our study displays several novel features. First, unconstrained by laboratory conditions, mobile eye-tracking allows participants to freely interact with a real artefact rather than with an image of a replica of the original (such as reported in Criado-Boado et al. 2019). Given the likely phenomenological gulf that separates viewing a thing from viewing an image of a replica-thing (Danto 1981), this has significant implications for the study of contemporary viewers. And it is worth adding that the original makers and users of many archaeological artefacts would never have seen an image of one and, aside from the decoration found on the pots themselves, would have had very little experience of 2D to 3D visual processing.

Second, a flame pot is a structurally unique artefact. Recording gaze-patterns of a static image of a flame pot would fail to draw out the embodied response that we are predicting. Documented reactions to flame pots from Okamoto (1953) to March (2020, 2022) talk of the viewer's desire to move:

> "…one experiences a strange shock from the unbelievably radical asymmetry […] the viewer begins to feel the urge to view it while circling all the way around the vessel." (Okamoto 1953, 54–55)

While not revealing anything directly about the experience of the original makers, studying the relationship between the body and eye movements of contemporary viewers can tell us whether a flame pot has the capacity to choreograph human behaviour and perhaps, by asking questions about what a flame pot does to people rather than what it means, brings us closer to its role in jōmon society. As mentioned above, evidence suggests that pots were used for cooking and feast preparation (Lucquin et al. 2016, 2018; Pearson 2007) whereas there is nothing to suggest that they acted as vehicles for symbolic content.

The current study aimed to test the following hypotheses drawn from research by the first author (March 2020, 2022):

- Direction of Gaze. Although the coiling pattern on the surface of the pot can be traced either clockwise or anti-clockwise, the sculptural form of the pot and overall organisation of spirals and linking lines on its surface suggest that there will be more eye movements showing a clockwise pattern.
- Direction of Movement. The clockwise organisation of the pot and its surface will result in more participants moving around it in a clockwise direction. That is, direction of eye movements and body movements will be mutually reinforcing.
- Prior Experience. Trained artists with more experience of engaging with visual material will be more sensitive to a pot's structure and will therefore show a higher proportion of clockwise eye and body movements than non-artists.

1.5.1. Method

The flame pot used for the study is in the permanent collection of the Sainsbury Centre for Visual Art, Norwich, UK (Figure 1.2). Participants viewed it in its normal location in the collection, on a grey plinth with a glass protective case. There is sufficient space around the pot to allow 360-degree access.

Eye-tracking was conducted with Tobii Pro Glasses 2 (50hz) which operates a tracking model to compensate for slippage correction and uses a one-point calibration procedure. We added a manual 8-point calibration check. The eye-tracking data were subsequently extracted by the Tobii Pro Lab in an unfiltered form and exported to ELAN (https://tla.mpi.nl/tools/tla-tools/elan/) for qualitative hand coding.

1.5.2. Participants

We recruited 25 (F= 15) participants from two populations: artists and non-artists (M_{age} 47.8, SD = 17.4). We excluded one artist participant because of equipment failure, leaving 24 participants (F =14). The eight artists (F = 6, M_{age} = 62.00, SD = 17.10) were recruited either from a local art university or local artist's network and all claimed visual art training. The 16 non-artists (F = 9; M_{age} = 40.69, SD = 12.86) were recruited via word-of-mouth. Those recruited as artists were exposed to art (either through making or viewing) more frequently than non-artists, with all artists engaging with art at least once a week (Table 1).

1.5.3. Procedure

Before viewing the pot, each participant completed consent forms, demographic information and scales assessing (a) underlying aesthetic fluency (Smith and

Smith 2006) and (b) experience of aesthetic flow using the Aesthetic Experience Questionnaire (Wanzer et al. 2018). The participant was invited to put on Tobii 2 eye-tracking glasses which were calibrated using the inbuilt calibration software, before also being checked manually. Each participant was given the following instructions:

> The exhibit is just behind here (indicates screen). I will show you which one it is in a minute. I want you to look at it as you would look at an exhibit in a museum. If you only want to look at it for 10 seconds, that's fine. If you want to look at it for longer, that's also fine. We will use the first minute but if you want to look at it for more than a minute, that's fine by us. When you have finished, find me here.

Upon returning the participant was invited to fill out the modified Aesthetic Emotions Scale (AESTHEMOS; Schindler et al. 2017) and asked to reflect upon whether their view of the pot had changed over the course of viewing it using a Likert scale where 1 represented "not at all" and 5 represented "very much". The full scales used can be found at https://osf.io/mktue/?view_only=0c126e17d1974900add68c8f2960a9a8

1.6. Results

1.6.1. Aesthetic Fluency and Flow

The artists scored significantly higher (M = 34.75, SD = 6.58) than non-artists (M = 19.5, SD = 4.44) on the aesthetic fluency measure, $t(22)$= 6.75, p < .001 and the measure of flow, $t(22)$ = 2.17, p = .041. (artists, M = 121.78, SD = 15.05; non-artists, M = 105.3, SD = 18.20) These differences confirm that the two groups represent two different populations.

Despite these differences and contrary to our hypothesis, the measured response to the vase did not differ significantly across the two groups. The artists did manifest a slightly higher aesthetic emotional response (M = 61.62, SD = 8.56) than the non-artists (M = 58.25, SD = 11.82) but this difference was not statistically significant, $t(22)$ = 0.72, p = .482. Likewise, the artists' view of the pot changed more (M = 4.00, SD = 0.75) than non-artists (M = 3.25, SD = 1.13), but again not significantly so, $t(23)$ = 1.69, p =.104.

Table 1.1. Frequency with which Participants Engaged in Making and Viewing Art. Copyright by authors

Frequency	Artists		Non Artists	
	Making	Viewing	Making	Viewing
Multiple times per day	5	6	–	1
Once per day	1	–	–	–
Multiple times per week	2	–	–	2
Once per week	1	1	1	3
Once per month	–	–	–	3
A few times per year	–	–	5	5
Once per year	–	–	7	1
No response	–	2	3	1

1.6.2. Eye and Body Movement Analysis

The structure of the artefact and the fluid nature of the eye-tracking data precluded automated analysis such as that reported in Criado-Boado et al. (2019). We therefore initially reviewed the 24 videos in an exploratory fashion and this review suggested two reasons to believe that pot structure and gaze pattern were correlated. First, the gaze of 22 of the 24 participants respected the boundaries of the pot and followed the contours of structure and pattern in similar ways such that it was difficult to distinguish one individual's eye movements from another's (see Figure 1.3).

Second, the habitual rapid saccadic behaviour of the eyes across the surface of the pot would be interrupted every few seconds when the gaze was described an eddying movement corresponding directly to an underlying spiral on the pot's surface. This is illustrated by heat maps which sum the frequency of gaze across participants (see Figure 1.4).

Subsequently, the eye-tracking videos were hand-coded both by the first author and a second coder. First, the total time spent engaging with the pot was recorded. Second,

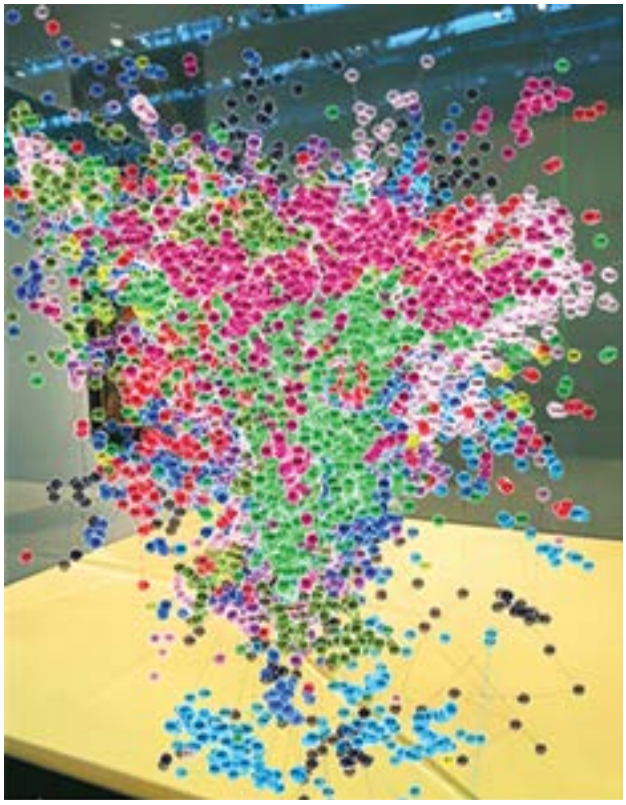

Figure 1.3. Fixation points for all 24 participants coded by colour. Copyright by authors.

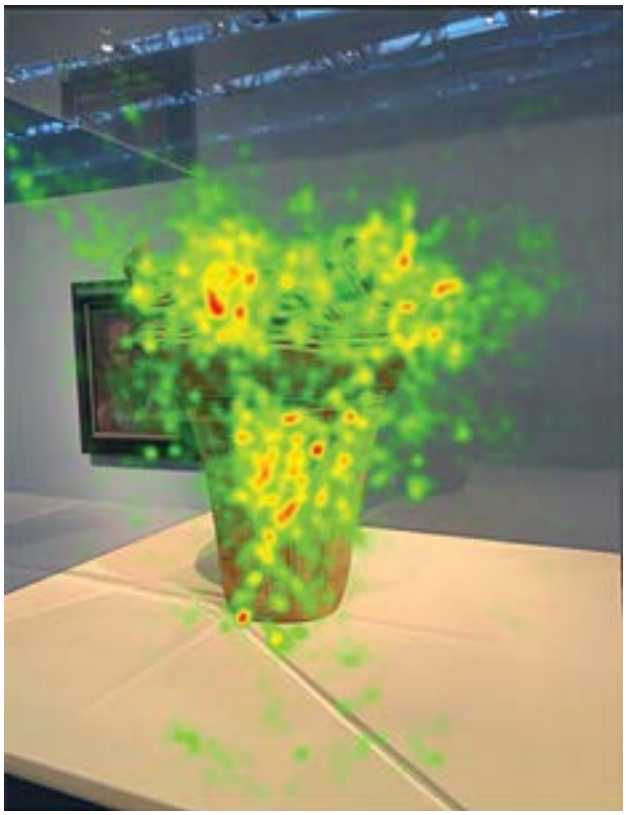

Figure 1.4. Heat map of fixations across 24 participants showing the spiral pattern of gaze. Copyright by authors.

the first 30 seconds of each participant's engagement of the pot was coded in two-second segments both for gaze direction (clockwise, anti-clockwise or neutral) and direction of travel (clockwise, anti-clockwise, neutral or forward/back).

1.6.3. Time Spent with the Pot

While artists spent longer looking at the pot (M = 119.63 seconds, SD = 49.7) than non-artists (M = 90.88, SD = 47.2) this difference was not significant, $t(22) = 1.38$, $p = .180$. Unsurprisingly, both aesthetic fluency and aesthetic flow were significantly related to the aesthetic reaction, $r(22) = 4.65$, $p = .022$ and $r(22) = .586$, $p = .003$ respectively. However, aesthetic reaction was most strongly related to the time spent with the pot, $r(22) = .770$, $p < .001$ (see Figure 1.5). Indeed, even when controlling for the effect of flow and fluency, the correlation remains between time spent and aesthetic reaction remains strong: $r(20) = .660$, $p = .001$. This suggests that, for artists and non-artists alike, the reaction to the pot is primarily a function of time spent engaging with it (or vice versa, since it's a correlation).

1.6.4. Direction of Gaze

The proportion of clockwise to anti-clockwise gaze movements are plotted in the left panel of Figure 1.5; clockwise gaze was much more frequent for both groups. In a 2 (gaze direction) × 2 (groups) mixed analysis of variance, the main effect of gaze direction was significant, $F(1, 22) = 20.27$, $p < .001$, but neither the main effect of group, $F < 1$, nor the interaction, $F(1, 22) = 1.27$, $p = .271$ were significant. This suggests that the structure and surface of the pot choreographed similar looking patterns for both groups.

1.6.5. Direction of Movement

Contrary to our prediction, we found that more participants initially took an anti-clockwise direction (see Figure 1.6,

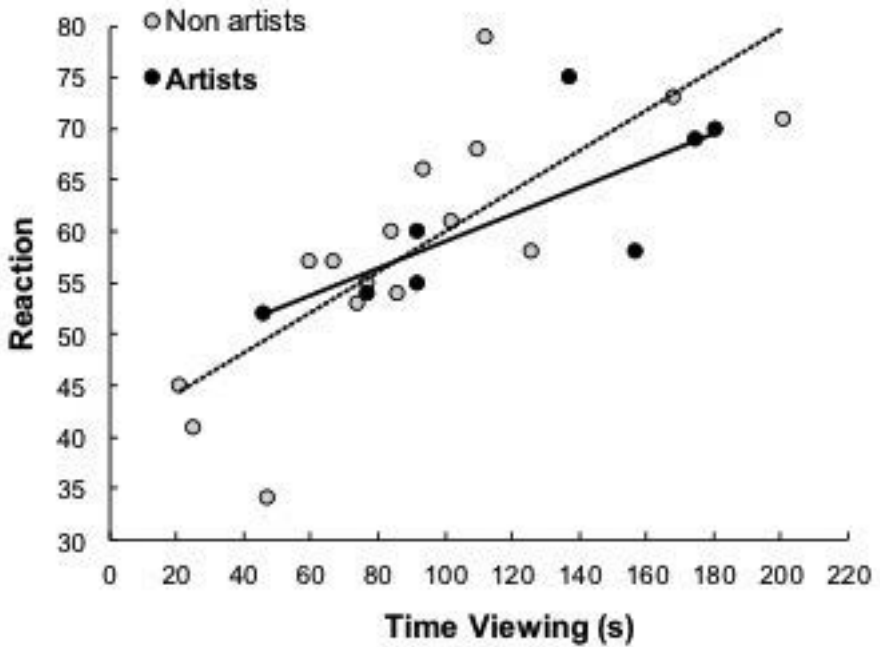

Figure 1.5. Reaction as measured with AESTHEMOS as a function of the time (in seconds) spent viewing the pot. Copyright by authors.

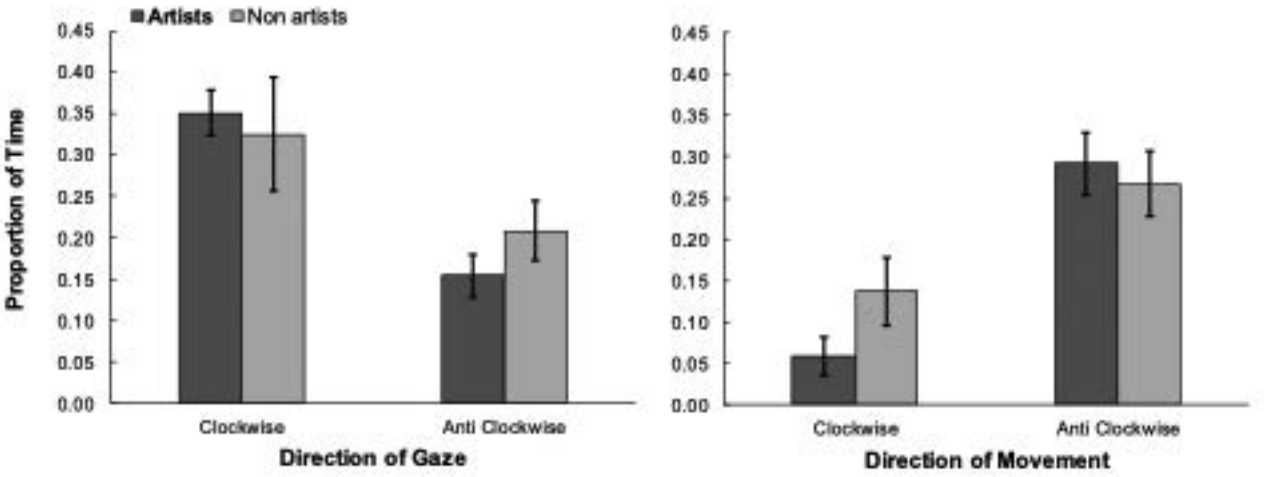

Figure 1.6. Proportion of time for clockwise and anti-clockwise gaze movement and clockwise and anticlockwise movement in both groups of participants. Error bars are standard errors of the mean. Copyright by authors.

right panel): 20 in total (12 non artists and all 8 artists). In a 2 (movement direction) × 2 (groups) mixed analysis of variance, the main effect of movement direction was significant, $F(1, 22) = 17.8$, $p < .001$, but neither the main effect of group ($F < 1$) nor the interaction, $F(1, 22) = 1.49$, $p = .235$, were significant. However, when we looked at change across time, 6 of the 8 artists finished by moving clockwise, one was moving in a neutral forward and back motion and one remained circling the pot anticlockwise. All the non-artists carried on in their initial direction. The full results can be retrieved from https://osf.io/mktue/?view_only=0c126e17d1974900add68c8f2960a9a8.

1.7. Discussion

The study reported here developed from a MET informed phenomenological analysis of the relationship between the act of modelling clay and the sensorial qualities of jōmon flame pots (March 2020, 2022). March's investigation made three propositions: first, the final form and surface structure of a flame pot can be experienced as an iconic enaction of the process of pot construction. Second, both the construction process and the iconic enaction will influence the patterns of engagement by subsequent users and viewers of the pot. Third, these patterns are therefore potentially discernible from pot morphology. Rather than viewing the pot as a medium for transferring meaning from one brain to another, the concept of enactive signification suggests that the interactions between a sentient body and its environment are, in themselves sense-making. Our aim was therefore to predict the body and gaze movements that a jōmon flame pot would enact in its viewers and to reveal this behaviour through video and mobile eye-tracking.

We tracked the eye movements of 24 participants (16 non-artists and 8 artists) looking at a jōmon flame pot in an unconstrained manner. We found the total time spent looking at the pot was significantly and positively associated with the strength of the aesthetic reaction for both artists and non-artists but, contrary to our initial hypothesis, we did not find significant differences between the behaviour of artists and non-artists on other eye tracking measures.

We predicted that the form and surface pattern of the pot would encourage participants' gaze to follow a clockwise pattern and to take a clockwise path as they walked around the pot. Whereas results did demonstrate that eye gaze was significantly more clockwise than anti-clockwise, we were surprised to find that participants' movements took a resolutely anti-clockwise path overall. Although unaware of any literature which compares movement patterns with gaze pattern across different planes, we had expected movement and gaze direction to be congruent.

On reflection, we suggest that this finding owes less to the characteristics of the pot, than to its situation. The pot is positioned about a metre from a panel, making it difficult to approach the pot from that direction, let us call it "north". This curatorially created context implicitly suggests the north perspective to be less interesting than the more accessible southern view, inviting viewers to perceive the south as the front and to begin their exploration from there. This perception is reinforced because the label is displayed on the south face. The participants' approach pathway was from the west so, to take a southerly position, they needed to describe an anti-clockwise arc. Approaching the pot from a distance, participants would be unable to discern its structural qualities, and so we suggest that museological context, rather than artefactual structure initially determine the route the participants take. However, in partial support of the idea that the artists would move differently and would also be more in tune with the morphology of the pot, all but one artist reversed the contextually constrained movement pathway as they engaged with the pot whereas the pot's structure did not influence non-artists in the same way.

Our exploratory video analysis produced two further observations. First, we were struck by how much the

participants moved around the pot. We had expected to find that artists would move more than non-artists but both groups manifested a similarly mobile response to the pot. We suggest that the sculptural dynamism of the pot and the unfolding deconstruction of symmetry experienced by viewers as they circled the pot facilitated and extended this response. Second, the detailed richness of situated data contrasts with earlier lab studies. We therefore suggest that in the future it would be interesting to investigate, first, whether our findings extend beyond jōmon pots to those pots displaying a more constrained morphology and second, whether our findings differ from eye tracking data from a two-dimensional image of the same object. Finally, the participants in our study were naïve observers with no knowledge of jōmon pots or culture. The eye gaze of jōmon scholars, let alone those of the original jōmon users might trace quite different patterns from those found here. Whereas we will never know how jōmon pots defined their makers' gaze, it would be interesting to investigate whether flame pots engage differently the contemporary eyes and bodies of those who know them best.

Overall, our study provided support for one of our three hypotheses, that of direction of gaze, and provided significant evidence of a consistent direction of movement in the opposite direction to that predicted although this did reverse for artists. There were suggestive differences between the engagement of artists and non-artists, but none were significant save the change in direction.

Mobile eye-tracking technology is new and relatively untested. In principle, it provides the opportunity to gather detailed information about how we look at situated objects, offering a new method for the empirical study of material culture. In archaeology, it may prove possible to map the relationship between the visual structure of artefacts and gaze patterns, thus enabling investigations into the influence of culture, tacit knowledge or expertise on the visual manipulation of objects. Current constraints on the technology relate more to the analysis than its deployment. The granularity of analysis required for the present study required hand coding which demands both time, training and is open to human error. Nevertheless, the research we report here is a first step and provides a concrete example of the benefits and limitations of this powerful tool.

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Ethics

The study has received a favourable opinion from the research ethics committee of the Faculty of Business and Social Sciences of Kingston University.

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