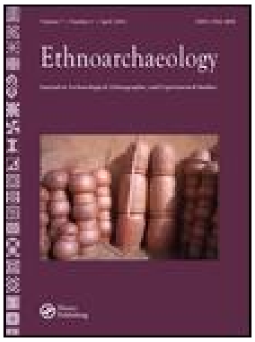

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No Experience, No Problem: Exploring the Role of Emulative Learning in Pipe Production

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No Experience, No Problem: Exploring the Role of Emulative Learning in Pipe Production

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ABSTRACT
Building on recent work by Braun [2012. "Petrography as a Technique for Investigating Iroquoian Ceramic Production and Smoking Rituals." *Journal of Archaeological Science* 39: 1–10, 2015. "Ritual, Materiality, and Memory in an Iroquoian Village." PhD diss., University of Toronto] and Smith and Major [2010. Ceramic Smoking Pipes." In *Report on the Salvage Excavation of the Antrex Site (AjGv-38): City of Mississauga, Regional Municipality of Peel, Ontario*, 78–91. Toronto: Archeological Services.], this investigation examines the potential for emulative learning in Late Woodland Iroquoian pipe manufacture. A comparative analysis of experimental data and pipe specimens recovered from the Antrex site highlights the considerable morphological variability in both assemblages, and suggests that pipe manufacture at Antrex may have been the product of emulative adoption guided by the visible aspects of ceramic convention.

KEYWORDS
Emulation learning; Native American; Iroquois; archaeology; smoking; pipe production; craft production; Ontario; Antrex

The interpretive value of Iroquoian smoking pipes has long been apparent to archaeologists working in the Northeast (Samet 2000, 331). Widely recognized as iconographically dense material aspects of past medical, religious, and social practices, pipes have made for useful proxies of past Iroquoian belief structures and ontologies (von Gernet 1995, 2000). As a result, pipe assemblage research has produced a number of robust chronologies of Iroquoian pipe use and cultural development extending from as early as the Middle Woodland period to historic contact (Braun 2012; Smith and Major 2010; Rafferty and Mann 2004). Despite this emerging narrative of Iroquoian pipe production, use, disposal, and change over time, the underlying mechanisms that may have influenced a number of important transformations in Iroquoian culture remain either poorly understood or highly contentious (Smith personal communication 2016). By building upon recent work by Braun (2012, 2015) and Smith and Major (2010) at the Antrex site, our own research has therefore focused on an investigation of emulative learning among novice craftspeople as a potential vector for the expansion of pipe use during the Late Woodland period.

Of particular interest is the sudden rise in Iroquoian pipe frequency during the Middle Ontario Iroquoian (MOI) stage (AD 1300–1400) in southern Ontario (Smith 1997, 1990, 285; Dodd et al. 1990, 321). This period witnessed a major transformation of smoking

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practices, as the raw number of pipe fragments found at Iroquoian sites increased dramatically alongside a shift to the manufacture of clay rather than stone pipes and a significant increase in the variability observed in pipe morphology (Braun 2012). In contrast to the exotic materials, careful construction, curation, and rarity of Middle Woodland pipes, examples of both crude and carefully constructed pipes made from a wider range of materials during the MOI also seem to suggest that there was a marked variation in technical proficiency among Late Woodland Iroquoian pipe-makers (Smith and Major 2010, 90). This implies that MOI communities, such as the Antrex site, demonstrate widespread, individualized production of ceramic smoking pipes for personal use (Braun 2015, 212; Braun 2012; Rafferty and Mann 2004, xii; Brown 1997, 474). That being said, questions still linger regarding the origins of such a development. For the purposes of this investigation, we have opted to focus specifically on questions relating to how pipe production was learned at the level of the individual. The high degree of variability observed in MOI pipe assemblages has suggested that pipe manufacture may not have been taught like other crafts and this potential absence of formal instruction has ultimately drawn our attention towards an evaluation of the role of emulation as an informal alternative to more traditional forms of craft learning.

Since its initial definition by Tomasello (1990), emulation, and, by proxy, imitation, has taken on a somewhat diverse set of meanings (Huang and Charman 2005, 277–279). Attempts to distill these meanings over the last ten years, however, have ultimately come to define emulation as the reproduction of results or outcomes *without* the replication of behavioral strategies or actions while imitation has been defined as the copying of a model's behaviors and/or actions in pursuit of similar results or outcomes (Nielsen 2006; Acerbi, Tennie, and Nunn 2011; Huang and Charman 2005). Emulation in this instance is therefore not focused on the *imitation* of a craftsperson's actions, but is more narrowly defined as the unguided replication of a finished product by an observer (Tehrani and Reide 2008, 318). In this case, the craftsperson is only concerned with the outcome of their efforts and is likely to be unfamiliar with the step-by-step technical processes employed by more experienced craftspeople (Tehrani and Reide 2008, 318; Acerbi, Tennie, and Nunn 2011). Emulators must therefore develop their own strategies or techniques in their attempts to reproduce similar end-states. Imitators, on the other hand, are aware of the behavioral steps required to produce a finished product and use that information to guide their actions. Because emulation learning is largely unguided, it may represent an important source of the significant variation within ceramic smoking pipe assemblages observed at important MOI sites like Antrex. By comparing the apparent variation within the Antrex pipe assemblage to the variance observed within a modern collection of emulated pipes, our study therefore seeks to highlight the potential role of emulative learning in the observed expansion of pipe production at Late Woodland Period Iroquoian sites.

Additionally, since our study straddles both the archaeological and psychological discourse on learning we have also striven to contribute beyond the archaeological literature. This is because studies focused on the nature of task-based learning modalities in living populations have tended to focus almost exclusively on the process of imitation or emulation in scenarios with fixed, binary results. In these studies, there are only two outcomes wherein the subject either completes or fails to complete an assigned task. We shift the focus away from the pass/fail nature of the test and more towards a scrutiny of how the goal of the exercise was pursued. Whether the subject achieves the desired result is largely irrelevant, as studies of this nature are primarily concerned with *how* the subject attempted to complete the task at hand.

Since studies of live populations with binary outcomes are not directly applicable to our research, we have endeavored to expand upon the literature of task learning by exploring imitation and emulation learning from the perspective of a variable end-state. With an eye towards the evaluation of quality and consistency in archaeological craft production, our study seeks to contribute a means through which we can gain a clearer understanding of learning modalities in past societies via their material outcomes. Our focus on a comparative analysis between a modern assemblage produced under controlled circumstances and similar collections of archaeological material bridges the gap in our knowledge from process to product and, ultimately, expands the toolset at our collective disposal when it comes to explorations of past social dynamics in varying forms of past craft production.

Following the preliminary investigations reported here, our results indicate that it may indeed have been possible that the adoption of clay as the primary medium of pipe production removed any significant "skill barrier" which may have existed with stone. Ceramic technologies therefore may have made pipes far more accessible to the general populace, and this can be seen in the highly variable forms, features, and styles of smoking pipes both from the Antrex pipe assemblage and our experimental collection (Smith and Major 2010).

The Antrex site

First discovered in 1990, the Antrex site (AjGv-38) was a Late Woodland Iroquoian longhouse village occupied during the mid to late thirteenth century AD (Williamson and Robertson 2010; Braun 2012, 1; Smith and Major 2010, 79). The site is located northeast of Lake Ontario (Figure 1) and consists of six longhouses, two large middens, an exterior activity area, and a palisade along the southeastern limits of the site (Williamson and Robertson 2010, 11). Village sites like Antrex were largely autonomous entities linked through exchange. Kinship was organized according to one's matrilineal descent and subsistence followed a mixed strategy blending agricultural production with hunting and gathering (Trigger 1985, 92; Warrick 2000, 439; Williamson and Robertson 1994; Crawford and Smith 2003, 220–231). Although regional differences have been noted, there is apparently little that distinguished Antrex from other Iroquoian sites situated along Lake Ontario (Braun 2012, 2).

Iroquoian pottery was manufactured using a variety of techniques and, despite the autonomy of villages, shared a limited repertoire of form and decorative style consisting of incised parallel and oblique lines with the occasional use of exterior punctates (Williamson 1990, 295–299; Smith and Major 2010, 81). Iroquoian pipes, however, demonstrate significant morphological variation (Dodd et al. 1990, 332; Braun 2012). Specifically, the smoking pipes recovered at Antrex display a high degree of variability in size, shape, temper, surface texture, and decoration (Smith and Major 2010). This suggests that there was a certain degree of formality and standardization in Iroquoian pottery production not seen in MOI pipe assemblages. As a result, it is likely that MOI pipe manufacture may not have been taught in the same manner as pottery production and instead may have belonged to a different class of individualized non-market craft production.

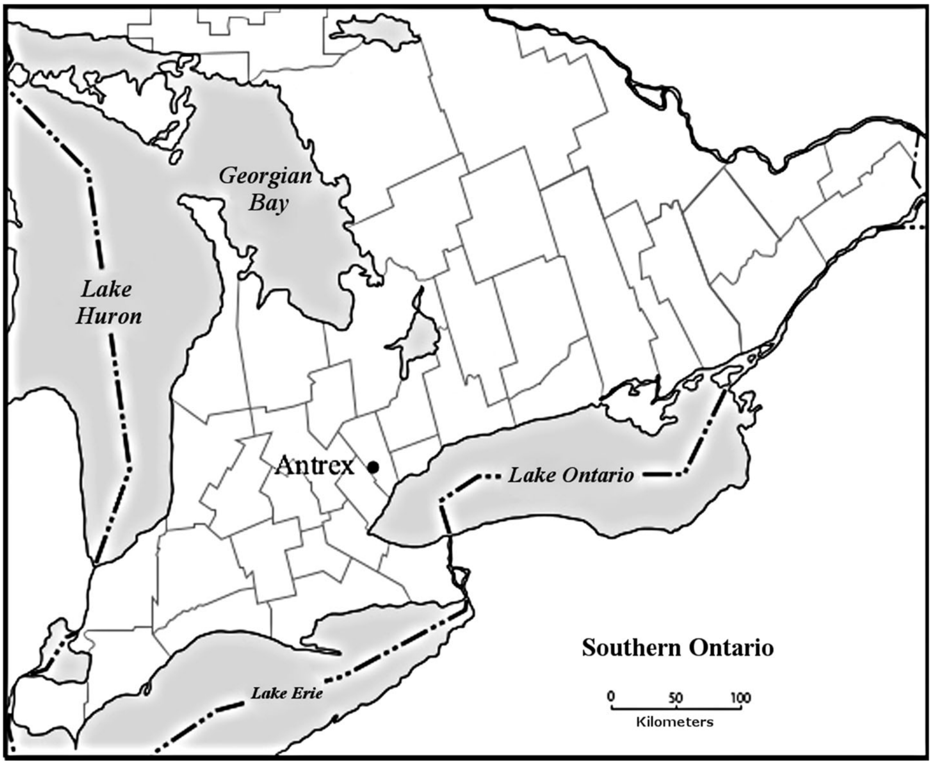

Figure 1. Map of southern Ontario showing the location of the Antrex site. *Modified from:* Southern Ontario-Regional Municipality Boundaries [computer file]. (n.d.).

Methodology

Experimentation with smoking pipe production was undertaken in three stages. The first stage was primarily concerned with determining viable techniques and methods of emulating a typical Antrex smoking pipe (Table 1). Experimentation at this stage was conducted with minimal reference to literature on pipe construction and without guidance. This was done in an attempt to best approximate the conditions of initial, unassisted pipe emulation among Iroquoian peoples. As such, despite a lack of clay-working experience, attempts to emulate Antrex pipe specimens (Figure 2) by the primary investigator through individual problem solving, trial, and error resulted in the development of four intuitive methods of pipe production and one documented Iroquoian manufacture technique that may have been utilized by novices. In addition to pinching, as noted by Braun (2012), these included: the drilling of a clay preform, construction on a wooden framework, the rolling of a clay sheet, and compound assembly (Table 1).

Our second stage experimentation was then concerned with the relative difficulty of pipe emulation by novice craftspeople and the discussion of any potential "skill barrier" to a wider adoption of smoking practices by Iroquoian peoples. With the assistance of student volunteers at the Royal Ontario Museum, our initial experimental findings could now be evaluated against experimental data provided by our test group. The test group was comprised of 28 individuals, each with varying backgrounds in ceramic production. Each member of the test group had at most 3 h of instruction and clay-working experience prior to the beginning

Table 1. Identified, experimental pipe formation techniques and results of Stage One experimentation.

Method	Steps	Results
Pinching	• Begin with a small ball of clay • Form exterior pipe shape by hand • Hollow out pipe bowl by hand • Hollow out pipe stem with a thin stick	• Crude, highly variable approximations of the reference material • Difficult and time inefficient
Roll and Fold	• Roll clay into flat sheet • Remove a triangular section • Roll into a hollow cone • Wet hands to close seam • Bend at roughly 90 degrees to form conical pipe	• Standardized with a moderate similarity to the reference material • Among the simplest, fastest and easiest methods
Preform	• Roll clay into a solid cone • Bend cone at 90 degrees • Hollow out pipe bowl by hand or with the use of a sharp stick • Hollow out the pipe stem with a thin stick	• Standardized with a high degree of similarity to the reference material • Very difficult and time-consuming
Compound	• Use any technique to form pipe bowl • form pipe stem by hand, drilling a preform, rolling, or forming on a wooden core. • Wet hands to close the seam between pipe bowl and stem	• Very poor approximation of the reference material • Most difficult and time-consuming method
Wooden Frame	• Begin with a stick bent at roughly 90 degrees • Add clay to wooden frame and form pipe exterior by hand • Expand and form the pipe bowl by hand • Wooden frame is removed during firing.	• Crude, highly variable approximations of the reference material • Very quick and easy

of our experiment. It is therefore fair to say that each of our test group participants can be considered novice craftspeople with little to no experience in pipe production.

In this stage, participants were tasked with emulating the form of a reference pipe produced by the primary investigator. Both photographs (Figure 2) and a physical replica constructed using actual Iroquoian techniques (Figure 3) were provided as reference materials. All variables for our initial experimentation and our emulative test group were strictly controlled apart from pipe formation technique itself. Technical choices were standardized via the use of very fine clay (Tucker's PHB earthenware) that does not require temper.

Following their emulation of the reference material, each pipe was photographed and each participant completed a survey outlining the key variables involved in the production process. Questions on the survey were focused on prior clay working experience,

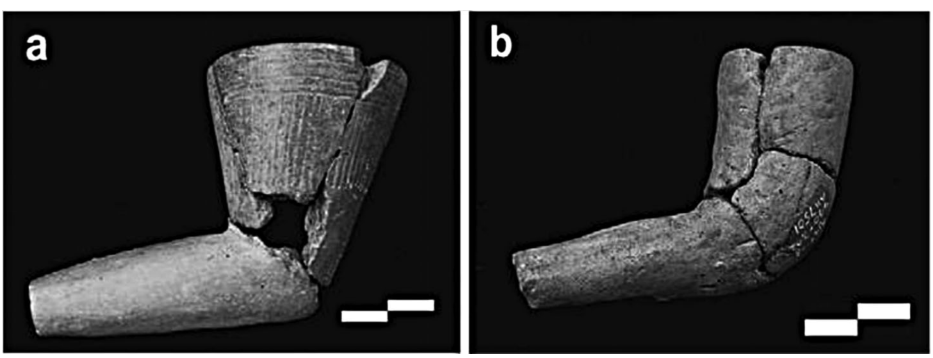

Figure 2. Antrex reference pipes. (a) A well-made pipe displaying evenly applied decoration, (b) a crudely made pipe with lumpy, uneven surfaces (reproduced with permission from Braun 2012, 3).

Figure 3. The physical replica provided to the emulative test group as reference material.

approximate time investment, number of attempts, subjective difficulty, and additional notes regarding their perceived level of success. Participants were also asked to outline their methods in as much detail as possible. Each pipe was examined and important variables noted. These included: overall size, shape, wall thickness, interior bowl size, exterior bowl angle, stem length, channel width, channel position, and observed similarity to the emulated reference pipe which allowed for the evaluation of test pipes in terms of both their appearance and functionality.

In this instance, measures of size and shape were used to help determine accuracy in pipe replication, while measures of channel width and position were important for determining each pipe's relative functionality. Criteria for a properly functioning pipe included: a minimum channel width of approximately 3 mm to allow for sufficient airflow, channel position near the bottom of the bowl, a pipe bowl angle between 90° and 180°, and an interior bowl size with a minimum volume of roughly 1 cm^3. Artisan ambition, decorative additions, and personal stylistic variation were also noted. Collected data were then compared internally and to the reference. This was intended to highlight consistencies between craftspeople and/or formation techniques, if any one technique produced the most similar results to the reference, and whether the assemblage's degree of unimodal variability defied the implementation of simple categories like at Antrex (Smith and Major 2010).

In Stage Three, our participants were asked to imitate pipe manufacture rather than emulate it. Our participant group was therefore provided with a demonstration prior to their own replication efforts (Figure 4). Specifically, participants in this stage were

Figure 4. The physical replica produced as a demonstration for the imitative test group.

shown the "preform" method due to its flexibility and ability to accurately replicate pipe features observed in the collection at Antrex. Stage Three experimentation was then undertaken so that degrees of variability in our emulated collections could be contextualized within a broader understanding of how more formal learning styles, such as imitation learning, might affect craft production outcomes and ultimately assemblage variability.

Following our analysis of internal variability and accuracy in pipe emulation for our emulative test group, we then compared our results to those derived from the Antrex pipe assemblage. Since members of the emulative test group were less likely to have had clay working experience than the community members at Antrex, our test group results were therefore expected to demonstrate a somewhat higher degree of internal variability than has been observed either at Antrex or in our imitative test group. This is because we have presumed that individuals with greater clay working experience are more likely to produce similar, more conventional results, which may have acted to constrict the degree of variability within the pipe assemblage at Antrex. However, since our study has been focused on a discussion of craft accessibility, we have chosen not to approximate the apparent diversity in clay working experience at Antrex and have instead focused on an analysis of production by true novices. This focus on novice craftspeople has, in turn, helped us to account for the possibility that pipe manufacture at Antrex may have been practiced by non-specialists. For example, if the degree of variability observed among the experimental and archaeological collections is similar, then it is possible that almost anyone may have been making their own pipes. Alternatively, if variability is significantly constricted at Antrex when compared to our emulative assemblage then it is more likely that Antrex pipe-makers possessed at least some form of prior clay working experience.

Results

Stage one

Preliminary results of our Stage One experimentation suggested that all five identified pipe formation techniques represent viable methods for producing a functioning pipe (Table 1). However, it is worth noting that each technique produced highly variable results. Finished products varied dramatically in almost every respect including size, wall thickness, aesthetic quality, shape, and similarity to the reference material. This is consistent with expectations derived from the analysis of pipe morphology conducted at the Antrex site where assemblage variability suggests that emulative learning may have resulted in the development of a more individualized set of ceramic pipe formation techniques (Smith and Major 2010).

Stage two

Our Stage Two experimentation suggested that qualitative observation may be somewhat more evocative than statistical analyses of raw dimensional variation. Two overarching trends made this particularly apparent. The first was a trend of high unimodal variability among the products of each of the participants and the second was the emergence of clear patterning among the survey results and experiences of the participants themselves. The results of Stage Two experimentation are therefore discussed here with the assistance of only basic calculations.

Of the 28 participants in Stage Two experimentation, only thirteen intuitively gravitated towards one of the five production modes outlined in Table 1, albeit each with some minor variation on the basic steps as listed. The remaining fifteen each adopted more novel variations via the integration of two or more different formation techniques as outlined. These variations were largely subtle adaptations and involved either the use of a wooden frame and non-triangular patterns when employing the "roll and fold" method or the employment of the "roll and fold" technique to produce the pieces required for a compound assembly. Overall, the test group produced nine wooden frame pipes, eight rolled pipes, three hand modeled pipes, eight compound pipes, no pinched pipes, and no preform pipes.

Strong consistencies in the experimental data were found in measures of production time and number of attempts. Each participant, with only three exceptions, took no more than 30 min and no less than 10 with the majority (65%) falling roughly around 15 min per pipe. More interesting were the number of reported attempts. Perhaps demonstrating clay's quality as an excellent learner's material, only eight participants (29%) required more than one attempt to finish their approximation of the reference material. Seven of these required only two attempts, and one outlier required five. This seems to be related to the low cost of error when working with clay. The lack of catastrophic failure and the ability to repair, patch, or rework an item before firing seems to have encouraged persistence and stylistic flourishes among the test group. Their finished pipes therefore displayed significant variation in every respect including measures of wall thickness, stem length, bowl angle, overall size, shape, and decoration. Notably, two of the more ambitious test group members even attempted to produce their own effigy pipes (Braun 2012) (Figure 5).

In fact, members of the test group who provided higher estimations of their initial clay working experience not only tended to choose some of the more difficult formation techniques but also took greater initiative with stylistic flourishes. These pipes, while still highly variable, seemed to represent a slightly restricted range in their variability, not completely unlike that observed at Antrex. Ultimately, however, pipes produced by the test group demonstrated only a low degree of similarity both to each other and to the reference material. Specifically, only one third of the pipes produced by the test group bore any non-trivial resemblance to the reference pipe. The remaining two thirds all demonstrated considerable stylistic variability. Examples of these stylistic traits include square pipe bowls, pipe stems of wildly varying length, and at least one pipe that can only be described as "unique" in its overall form. Despite their high degree of variability, it should also be

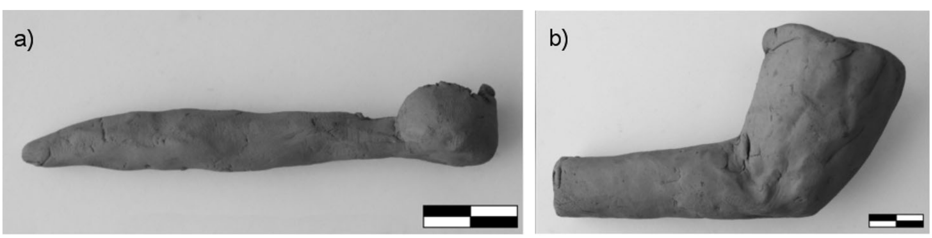

Figure 5. Examples of extreme variability among the emulative test group pipe assemblage. (a) A crudely made, stylistic replication of the reference pipe, (b) an accurate replication of the reference pipe.

noted that 24/28 of the test group pipes appear to be functional based on their composition and dimensions as outlined earlier. Due to the nature of wet clay, pipes were not tested for functionality but air was able to pass through each pipe and pipe bowls were generally well made. It is also worth noting that fired test group pipes all remained functionally viable after firing.

Stage three

Stage Three experimentation, as expected, produced a noticeably higher degree of similarity to the provided reference pipe. Of the 16 members who participated in Stage Three, none attempted to stray from the demonstrated "preform" method of pipe manufacture. As a result, pipes produced in Stage Three were consistent both in form and style (Figure 6). No undemonstrated decorative flourishes were present in the final assemblage and variability in size clustered relatively tightly. Participants in Stage Three noted a significant decrease in construction time when compared to Stage Two, with times to completion clustering around the 5–10 min marks. In similar fashion to Stage Two, almost every pipe produced (15/16) appeared to be functional. However, pipes were not fired at this stage and although it is likely that they would have remained intact, we cannot say with absolute certainty how many would have survived.

Antrex

Pipes recovered from Antrex demonstrate a significant degree of morphological variation in size and shape that is similar to the variability observed in our emulative assemblage (Figure 7) (Dodd et al. 1990, 332; Braun 2012). Indeed, Smith and Major (2010, 81) suggest that pipes recovered from Antrex do not share a single characteristic size nor can they be organized into simple modal ranges such as small, medium, and large. In addition to overall size, surface texture (majority polish or smooth), temper grit, interior bowl profile (the majority straight, convex, or convex-straight), exterior bowl angle, and collar presence are also highly variable. Furthermore, 60% of pipe bowls are decorated, but are primarily (~80%) simple in design—horizontal lines concentrated along the upper portion of the bowl—with the rest remaining highly variable (Smith and Major 2010, 84).

Despite the marked variability of the pipe assemblage at Antrex, a number of similarities can be found in the angle where the stem and bowl meet (which consistently fall between 90° and 110°), orifice shape (overwhelmingly rounded with the exception of two rectangular

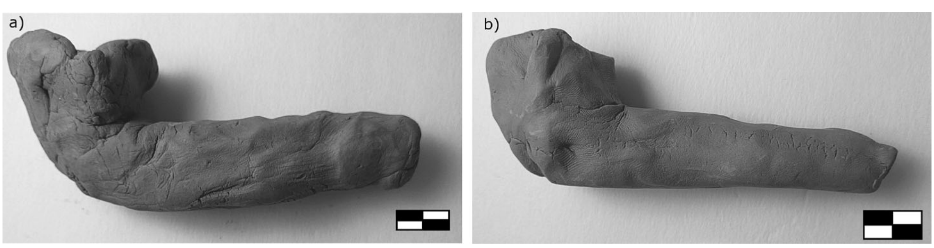

Figure 6. Examples of restricted variability among the imitative test group pipe assemblage. (a) A crude, expedient replication of demonstrated technique and reference material, (b) a careful replication of both technique and reference material.

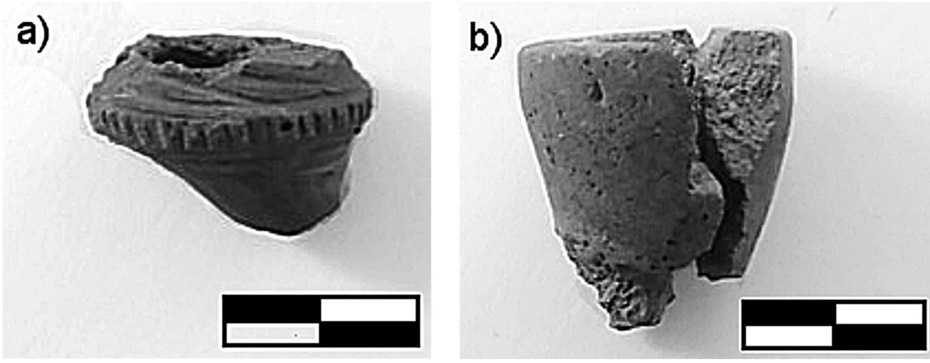

Figure 7. Antrex pipe variability. (a) A small, very finely decorated pipe bowl, (b) a relatively large pipe bowl with surface voids and lacking in decoration.

bowls), bowl lips (flat or slightly rounded), lip decoration (almost entirely absent), and decorative motifs confined to the exterior surfaces of pipe bowls bearing similarity to those applied on pottery (Braun 2012, 1; Smith and Major 2010, 84). Additionally, Smith and Major (2010, 84) note that exterior pipe bowl forms at Antrex can be divided into four broad categories based on *bowl orientation* and *exterior bowl profile*—Cylindrical (vertical and straight), Barrel (insloping and straight to convex), Conical (vertical and convex), and Trumpet (outflaring and concave). Furthermore, profiles seem to be primarily rounded or ovate, and 60% of mouthpieces are plain and undifferentiated from the stem. Interestingly, four specimens are D-shaped or tri-cornered—profile shapes present in preceding pipe assemblages from Princess Point to Uren (Smith and Major 2010, 84). Iroquoian pipes in this instance also appear to present something of a continuum in overall quality and care (Braun 2012, 2). This suggests that Iroquoian pipes may reflect a broad range of varying skillsets on the part of their craftspeople (Braun 2012, 2). The relative consistency among pottery when compared to smoking pipes also suggests that the former was likely to have been produced by small groups for widespread consumption while the latter was a more widespread and individual affair (Braun 2012, 1, 2015).

Discussion

The analysis of our experimental findings has produced a number of interesting implications for the interpretation of patterns observed within smoking pipe assemblages from across the Northeast, especially when contextualized with reference to the smoking pipe assemblage at Antrex. In this instance, it is worth noting that although the emulative test group and Antrex have both produced assemblages with considerable internal variability, there is still a non-trivial difference between the two. This is because there was a somewhat higher, albeit not unexpected, degree of variability among members of the test group than has been observed at Antrex. Both Antrex and the emulation test group produced large and small pipes with walls of highly variable thickness, bowl angles between 90° and 110°, pipe stems of differing length, a range of decorative flourishes, and the occasional non-conical pipe form (Smith and Major 2010, 80–84). Even the more extreme or "unique" pipes produced by the test group, including examples of rectangular pipe bowls, appear to have had parallels at Antrex (Smith and Major 2010, 81). The difference between them is therefore largely evident in the extent to which these traits were expressed.

Despite this variability, the clear majority of emulated test group pipes were still functional since their channel placements all aligned with the pipe bowl, channel widths all matched the minimum diameter of 3 mm, pipe bowl angles all fell between 90° and 180°, and pipe bowl dimensions were all at least 1 cm^3 in volume. This was regardless of the specific pipe formation technique employed or the relative level of stylistic ambition exhibited by test group members. A theme of ease of access in ceramic pipe production has therefore become apparent. There appear to be few, if any, wrong ways to make a pipe. This means that ceramic technologies likely presented little or no “skill barrier” to prevent the adoption of smoking practices by novices and lends some additional support to the possibility of individualized pipe production at Antrex (Braun 2012, 8, 2015). The ubiquity of ceramic vessels at sites across the Northeast also suggests that ceramic technologies would have been widely available and access was therefore unlikely to have posed a problem for members of Late Woodland MOI villages. Late Woodland Iroquoian peoples therefore had both the means and opportunity to accompany a broad range of potential social and iconographic motives for the widespread adoption of smoking practices.

That being said, the role of emulative learning at this stage still remains somewhat nebulous. This is because the comparatively reduced variability of Antrex pipes when compared to those produced by the test group may signal the presence of some degree of external guidance or of cultural rules regarding the “proper” form expected of a pipe that fulfills certain utilitarian, social, and symbolic functions. The presence of pipe formation guidelines may also be supported by the consistent use of dark colored materials as temper over other, more appropriate, stone (Braun 2012, 2015, 118–119). It seems more likely, however, that the reduced variation in pipe morphology at Antrex was instead a reflection of a more developed ceramic skillset possessed by MOI pipe-makers than those who participated in the test group. This skillset disparity is perhaps best highlighted with reference to the employment of decorative motifs in pipe production. For example, decoration among the members of the test group was sporadic and variably ambitious with no clear consistency, while pipe decoration at Antrex shares significant continuity with motifs that are generally found on pottery (Smith and Major 2010, 81; Braun 2012, 2).

Although common decorative motifs and the employment of similar modeling techniques in both pipe and pottery manufacture at MOI sites have reinforced parallels between the production of both technologies, pipes still tend to display a much broader range of variation in their manufacture (Dodd et al. 1990, 332). For example, our analysis of pipe bowls at Antrex has revealed that while some were more likely to have been formed by hand, others appear to have been drilled or hollowed out with the aid of a small, unknown implement. Pipe-makers at Antrex therefore appear to have been unconstrained by a set of standardized practices and this may be reflective of the individual and emulative nature of their learning process.

This makes a critical implication regarding the nature of pipe manufacture at Antrex. The extent to which pipes mimic pottery formation techniques and decorative motifs suggests a certain degree of clay working experience among even the lesser skilled craftspeople represented within the pipe assemblage. This experience with ceramic technologies may have guided craftspeople towards specific manufacture techniques, restricted variability in form, and inspired decoration consistent with that of locally produced pottery. This is, of course, in stark contrast to the high degree of variation demonstrated by the relatively unguided and inexperienced emulative test group. Conversely, members of the imitative test group, who received basic instruction, all produced much more consistent results (Figures 5 and 6). The effects of experience in constricting variability from the reference material were significant and this implies that MOI pipe-makers were therefore unlikely to have been complete novices. In this scenario, emulative learning of pipe manufacture is still a very real possibility, with the final products displaying less extreme variation than the test group due largely to the constricting effects of their own experience and their ability to adhere more accurately to ceramic and smoking pipe conventions.

The role of emulation constricted by basic experience is further supported by a petrographic analysis of clay fabrics and discussion of decorative consistency at Antrex (Braun 2012). In this case, pottery displayed a much greater uniformity in clay fabric production and decoration when compared to smoking pipes. Ceramic vessels ($n = 1299$) were produced with a comparatively restricted range of raw materials, used consistent types of stone as temper, and demonstrate a much higher degree of consistency and skill in their decoration with a coefficient of variation (CV) of ~3% (Braun 2012, 5–7). On the other hand, the assemblage of 146 smoking pipe fragments were made using a broad range of raw materials, use of temper was inconsistent or absent, and CV measurements of decorative consistency varied from 3% to 38% (Braun 2012, 7). This suggests that, in contrast to the proficiency of MOI potters, pipe manufacture was likely to have been performed by individuals with highly variable skillsets (Braun 2012, 7).

Such a high degree of variation in the technical details of pipe manufacture means that there was also likely to have been little to no guidance for novice Iroquoian pipe-makers and this supports the notion that emulative learning may have been largely responsible for much of the variation observed both in the emulation test group and at Antrex (Tehrani and Reide 2008, 325). This is because such technical details are not often visible aspects of a craft-person's final product and are therefore less likely to have been consistently applied within an emulative framework. Unlike technical choices involved in clay fabric production, temper, and firing; however, decoration and form are both highly visible aspects of smoking pipes. These highly visible traits act as the primary focus of emulative craft production efforts and are therefore likely to display a higher degree of consistency than less visible technical choices in the absence of instruction. This is further reinforced by the emphasis on stone materials used as smoking pipe temper (Braun 2012, 2015). While potters relied on a restricted range of igneous stone, pipe-makers either did not temper their pipes or exploited a much broader range of materials including sedimentary rock, calcite, sand, and wood charcoal (Braun 2012, 2015, 118). In this case, the more consistent appropriation of the visible aspects of pottery in pipe manufacture over those less visible technical processes like temper selection suggests that pipe manufacture may have been essentially unguided and thus may also be reflective of emulative learning at Antrex.

The apparent lack of guidance in pipe production at Antrex is further supported by comparisons of results from our Stage Two and Three experimentation. To this end, we selected the 16 most accurate replications produced during Stage Two experimentation for comparison with those produced in Stage Three. This was done primarily so that the constricting effects of formal instruction on craft production variability could be understood under ideal conditions. In comparative measures of bowl width, bowl height, and stem length, pipes produced via imitation all demonstrate a significant reduction in their overall variability compared to those produced within an emulative framework (Figure 8). In our emulation test group, measures of bowl width ranged from 2.45 to 3.9 cm, bowl height extended from 4.2 to 6.4 cm, and stem length fell anywhere from 6.5 to 9.4 cm with each measurement clustered around means of 3.26, 5.37, and 8.17 cm respectively. In the imitation test group, however, measurements of bowl width, bowl height, and stem length ranged from 2–2.9, 3–4.4, and 9–9.8 cm with each measurement clustered around means of 2.37, 3.72, and 9.4 cm respectively. As a result, even with emulative outliers removed, pipes produced via emulation still produced a significantly broader normal distribution curve than their more tightly clustered counterparts from the imitation test group (Figure 8).

In addition, pipes produced via imitation also demonstrated a much closer overall resemblance to their respective reference material. This is because, unlike in the emulation group, members of the imitation test group did not experiment with any form of alternative pipe formation technique nor were they concerned with the more stylistic or decorative aspects of pipe manufacture. Participants in the imitation test group were instead primarily concerned with a strict imitation of the explicit steps presented to them. Perhaps unsurprisingly, this suggests that the tendency of participants to follow demonstrated procedures may also have a significant normalizing effect on the outcomes of a replicator's actions.

Having established an experimental baseline of variability associated with both formal and informal craft learning, we can now contextualize our findings with respect to the pipe metrics observed at Antrex. In this instance, however, we used our whole emulative dataset and incorporated a larger overall sample from the Antrex pipe assemblage ($n = 28$). This has been done to ensure that the full range of variability across all three of our assemblage datasets is accurately represented and to avoid any potentially introduced biases or distortions in our projections. With the full assemblage included, emulative measures of bowl width range from 1.25 to 3.9 cm with a mean of 3 cm and measures of bowl height range from 1.5 to 6.4 cm with a mean of 4.88 cm. Additionally, measurements of bowl width and bowl height at Antrex range from 1.5 to 4.35 cm with a mean of 3.02 and 3.5–6.6 cm with a mean of 4.71 cm respectively. When compared in this way, the relationship between the Antrex pipe assemblage and those produced by our two test groups becomes much clearer.

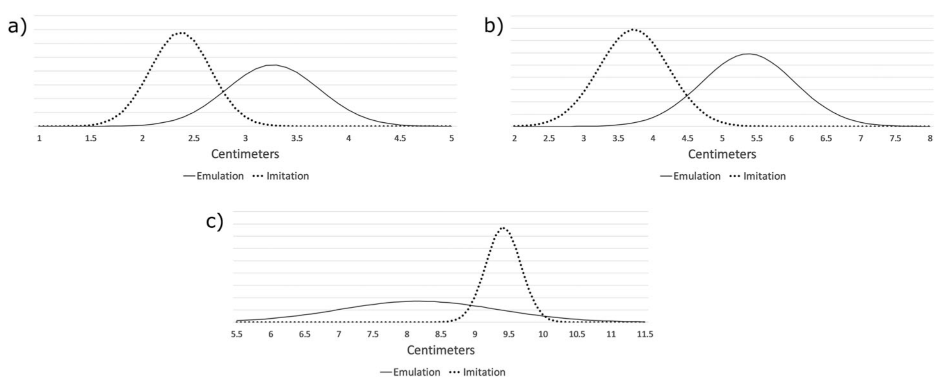

Figure 8. Univariate distribution curves of (a) bowl width, (b) bowl height, and (c) stem length in emulative and imitative test group pipes with outliers excluded.

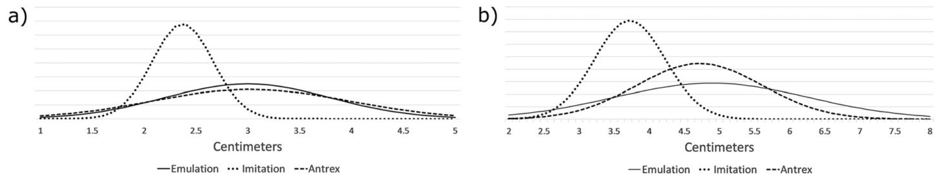

Figure 9. (a) Univariate distribution curves comparing measures of (a) bowl width, (b) bowl height, and (c) wall thickness at Antrex to measurements observed in our emulative and imitative assemblages.

In similar fashion to our experimental comparisons, measures of bowl width and bowl height with CV values of 31.2% and 18.9% at Antrex, 26.5% and 28.3% in the emulative test group, and 12.3% and 13.5% in our imitative test group have once again proven to be of particular interest. This is because, with the inclusion of pipe bowl data from the Antrex site, a few key trends begin to emerge. With respect to bowl width, for example, what becomes immediately apparent is the very close relationship shared between our archaeological and emulative datasets. In fact, the relationship evident in their distribution curves, as highlighted in (Figure 9(a)), is so close that it cannot be justifiably dismissed as merely coincidental. This trend is also visible, albeit to a lesser degree, in measures of bowl height. Despite the less striking nature of the relationships between Antrex pipes and the products of our emulative test group in other measures (Figure 9(b)), however, they remain significant. This is because although the degree of variability observed within the Antrex pipe assemblage falls between our emulative and imitative assemblages, it still retains a noticeably closer relationship to the latter as demonstrated in their respective distribution curves.

This reinforces the notion that the Antrex pipe assemblage was likely the product of emulation learning mediated by varying degrees of personal clay working experience or cultural rules associated with pipe manufacture. Since Antrex pipe measurements do not cluster as tightly as novice-produced imitative pipes, it follows that imitative learning was unlikely to have been responsible for the high degree of variability observed in MOI pipe assemblages. Instead, statistical evaluations of experimental imitation and emulation learning in pipe production suggest that trends observed at Antrex are more characteristic of an emulated, rather than an imitated, assemblage.

Unfortunately, because tobacco can still be consumed without need for a pipe, the reasoning behind the noted increase in pipe assemblage size as observed at Antrex remains somewhat more speculative. Causes for the sudden ubiquity of pipes at MOI sites like Antrex, for example, may range anywhere from being linked to an increase in overall accessibility to a result of increased demand brought on by the intentional destruction, rather than curation, of otherwise still functional pipes (Braun 2015). As a result, although findings presented here have highlighted the potential role of emulative learning in MOI pipe production, further investigation of the social and ritual underpinnings of Iroquoian smoking practices is still required.

Conclusion

In sum, there is a strong case to be made for the role of emulative learning and informal craft production in smoking pipe assemblages at MOI sites like Antrex. All five identified methods of pipe manufacture tested experimentally by participants without any prior clay working experience produced viable pipes and this has been reinforced by findings from within our emulative test group. It seems then that there is no apparent skill barrier in the production of Iroquoian ceramic smoking pipes. The lack of catastrophic failure when working with clay and the draw of personal taste also seems to have encouraged the high degree of variability observed within the test group and this may have also encouraged variability in specific traits among the Antrex assemblage as well. The slight reduction in variability at Antrex compared to the test group also implies that at least some pipe-makers at Antrex were likely much more familiar with ceramic technologies and this familiarity is likely responsible for the restriction in decorative motifs to those found on pottery. The selective copying of these decorative motifs alongside the inconsistency in less visible technical choices further implies that pipe-makers at Antrex were not taught the intricacies of ceramic manufacture but were instead merely emulating or copying what they saw around them both in pipe and ceramic manufacture. Coupled with clear markers of variable skill among MOI pipe-makers, it is therefore likely that at least a proportion of the population at Antrex learned their craft "the hard way."

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